TASMANIAN ENERGY AUDITS:

ANALYSIS OF AGED CARE BUILDINGS

by

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STATEMENT

The thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the thesis, and to the best of the candidate's knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the thesis.

Signed______

Pakinee Hingston

ABSTRACT

One of the major contributors to energy consumption in commercial buildings is the health care sector. Within this sector, aged care organisations are second only to hospitals in terms of energy consumption. However, very little research has been conducted in Australia on energy performance in aged care organisations. Hence this study investigates the potential for reducing energy consumption in Tasmanian aged care buildings. Energy audits were conducted in four Tasmanian aged care buildings in Hobart. Energy use per unit floor area in Tasmanian aged care organisations was used as an energy consumption index to allow direct comparisons to be made with countries with the best practice energy standards. The 25% of aged care buildings with the lowest energy consumption levels from each of Denmark and United Kingdom were chosen as benchmarks. It was found that the average Tasmanian aged care organisation consumed around 235 kWh/m^2 per year which is at least 63 kWh/m^2 per year more than these benchmarks. Most of the 63 kWh/m^2 energy reduction target can be achieved through energy saving investments with short payback periods, such as sealing vented skylights, installing hot water flow control valves, HPS for outdoor lighting, and controlled flow shower roses, together with improving their energy management and housekeeping. Medium term measures, such as additional roof insulation and installing CFL for residential room lighting, may also be required to meet all of the target.

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CHAPTER 1

INTRODUCTION

This thesis examines *the potential for reducing energy consumption in Tasmanian aged care buildings.* This introductory chapter provides a background to research on energy audits in Tasmanian aged care buildings, and also outlines the hypothesis, aims, limitations, methods of the study, and structure of the thesis.

1.1 THE RESEARCH BACKGROUND

In a commercial building, the major energy source is electricity (Ballinger 1991: 49). Nationally, 20 percent of total electricity generated are directed to commercial buildings and associated uses (Energy Victoria 1994: iii). The commercial sector has been the fastest growing sector of the Australian economy over the last decade (Pupilli 1991: 29). In the 25 years prior to the 1997-1998 financial year, electricity consumption more than tripled in the commercial sector (Dickson and Warr 2000: 1). This growth has also been reflected in the increase in its electricity consumption.

Many environmental problems have resulted from increased electricity generation to meet the growing demand for electricity. In particular, burning of fossil fuels has contributed to the enhancement of the greenhouse effect, causing global warming (Motta 1994). Hence, reductions in energy consumption are desirable. Furthermore, conserving energy is inherently economical; investing in efficiency is often highly profitable in all sectors of the economy (Vorsatz 1996: 2).

However, there are two fundamentally different ways of looking at how buildings can be improved from an energy point of view. These are the energy efficient building concept and the low energy building concept (Abel 1994:170). The energy efficient building concept aims to create a building that, in every detail, has the lowest possible energy requirements. This can often be formulated as the lowest possible need for energy within reasonable economic limits. In contrast, the low energy building concept aims to create a building that requires no external supply of energy or, at least, no supply of purchased energy. This is usually applied to one-family house concepts, rather than commercial buildings. Hence, the energy efficient building concept is applied to most commercial buildings.

One of the major sectors of energy consumption is health care buildings. Their high levels of energy consumption compared to other commercial buildings is partly due to usually being occupied 24 hours per day (Centre for Advanced Engineering [CAE] 1996: 256, Lincolne Scott Australia Pty Ltd and AT Cocks and Partners Pty Ltd [LSA&ATCP] 1996: 81, Santamouris *et al.* 1994: 295, 1996: 66). Hence space heating and lighting, along with water heating, are the dominating end uses (Energy Information Administration [EIA] 1994: 14). In aged care organisations, energy is one of the largest controllable costs in running their buildings (Department of the Environment [DOE] 1997c: 2). These two important observations suggest that aged care buildings, or 'old people's homes', warrant particular attention by energy managers.

In the process of reviewing many research papers related to energy conservation in health care buildings, it was apparent that a large amount of research has been carried out on hospitals and clinics. Unfortunately, it was also apparent that very little research has been conducted in Australia on energy audits and energy management in aged care organisations.

1.2 Statement Of The Hypothesis

Consequently, the hypothesis of the study is: *"Energy performance of Tasmanian aged care buildings meets overseas best practice energy standards"*.

1.3 The Research Aims

This study aims to investigate how to improve energy efficiency in Tasmanian aged care buildings by conducting energy audits. The specific aims of this research are:

1) to investigate the energy consumption of Tasmanian aged care organisations, highlight areas of substantial energy use, and relate the relative energy consumption of each building with particular characteristics known to influence energy efficiency;

2) to determine what is 'best practice energy standards for aged care buildings', and which countries have best practice in energy standards for aged care buildings; and

3) to identify the energy performance of Tasmanian aged care organisations by comparing with energy standards for aged care buildings from the best practice countries.

Comparing the energy performance with energy standards or energy consumption targets can indicate the potential for improvements, and allows comparisons to be made between buildings in a group or estate (Horwood 1993: 12, DOE 1997c: 14).

1.4 The Limitations

This thesis does not attempt to supply highly evolved engineering information on energy efficient technologies, but seeks to provide a comprehensive information source for aged care organisations, and focuses on considerations of using energy efficiency technologies.

The study is undertaken over a two year period in fulfilment of the requirements of the degree of Master of Environmental Studies (research). Due to time constraints, energy audits in the four aged care organisations are restricted to the 15 months from November 1998 to January 2000.

1.5 Methodology

A range of research and analysis activities are employed, including:

⇒ Review and documentation of case studies related to energy management and energy efficient technologies.

⇒ Conducting energy audits in four aged care organisations in Hobart. The data from this is interpreted, analysed, and compared with other studies. A discussion of options for improving the efficiency of energy use in the buildings is provided.

⇒ Interviewing people in the aged care organisations, including Maintenance Supervisors, General Staff, and Business Managers. To assess levels of knowledge of energy use, identify existing problems, and determine potential for improvement.

1.6 THE STRUCTURE OF THE THESIS

This thesis is presented in six chapters. The structure of this thesis is shown diagrammatically in the flow chart in Figure 1.2.

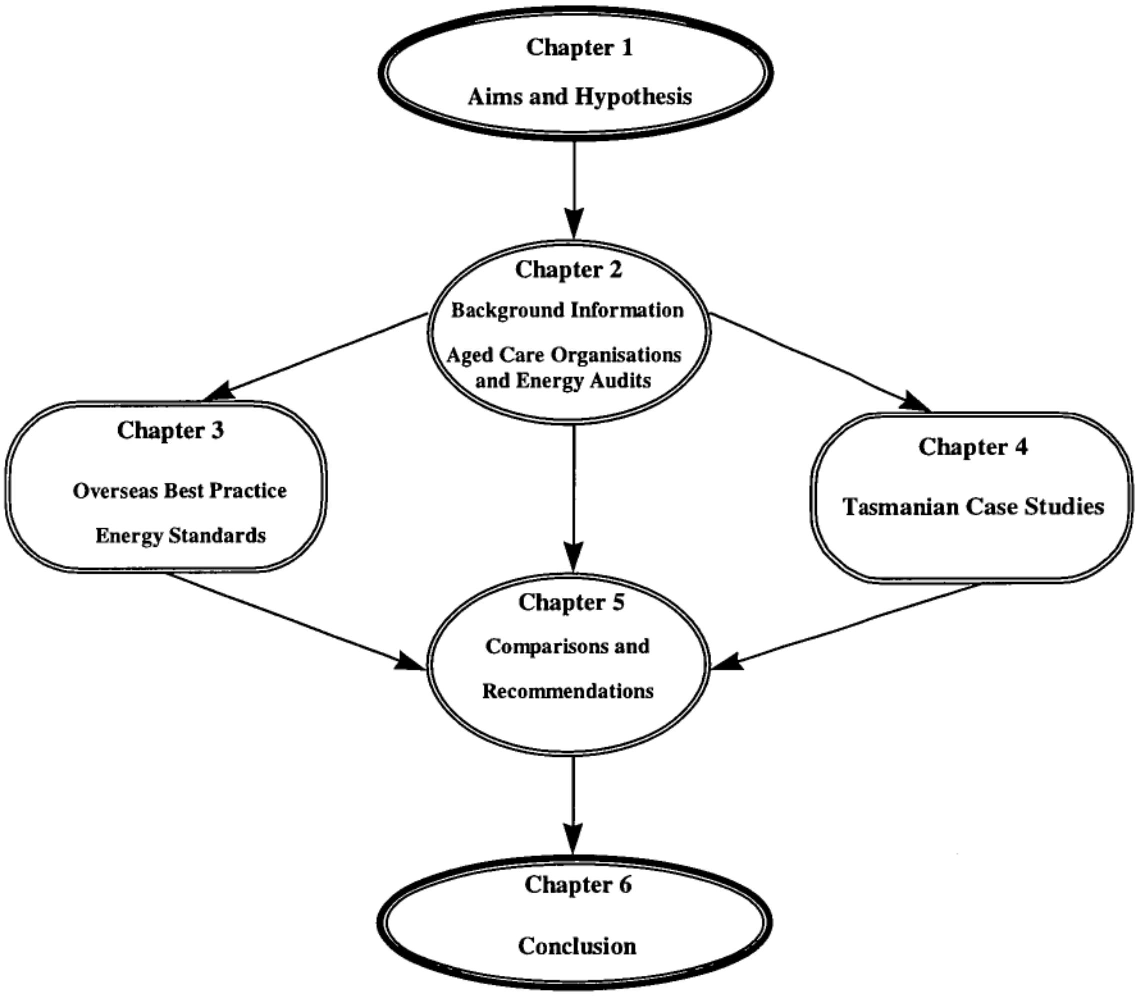


FIGURE 1.1
Flow chart indicating the structure of the thesis

Chapter 1 is the introduction. Chapter 2 gives background information on energy management, energy audits, and aged care organisations along with their major technologies used. Chapter 3 identifies which countries have the best practice energy standards for aged care organisations. Chapter 4 provides results and discussion of conducting energy audits in four Tasmanian aged care organisations in Hobart.

Chapter 5 compares the energy performance of Tasmanian aged care buildings with the overseas best practice energy standards. Data from Chapter 3 and 4 are referred to in order to assess the comparisons. The results from the comparisons and the need for energy conservation of Tasmanian aged care organisations are discussed. Chapter 6 is the conclusion.

CHAPTER 2

BACKGROUND TO ENERGY AUDITS IN AGED CARE BUILDINGS

This chapter presents a brief overview of background information on energy management, energy auditing, and energy use in the health care sector. Background information is divided into two sections. The first section provides information on energy management and building energy auditing procedures; and the second section describes energy uses in the health care sector, including major technologies used by aged care organisations which relate to energy consumption.

2.1 ENERGY MANAGEMENT AND BUILDING ENERGY AUDITING

2.1.1 Introduction

Energy conservation, energy management and energy auditing all have been issues of growing concern worldwide since the 1973 oil embargo (Hunt 1983: 3). In many countries, including Australia, energy conservation studies have been conducted and national energy plans have been launched.

The Commonwealth's National Energy Efficiency Program (NEEP) was substantially revised in 1990. The NEEP undertook initiatives in commercial sectors including minimum energy performance standards (MEPS), labelling schemes, commercial building energy codes and efficiency audits (Australian Government Publishing Service 1996: 44). However, the initiatives for the NEEP have become parts of the existing measures for the National Greenhouse Strategy (NGS). A number of other energy conservation programs have also been established and many Australian Standards have been published relevant to the efficient use of energy. For instances, Enterprise Energy Audit Program (EEAP) (DPIE 1991a), Australian Standard 3598-1990 (Energy management programs - guidelines for the preparation of an energy audit brief), and Australian Standard 3596-1992 (Energy management programs – guidelines for definition and analysis of energy and cost saving).

In 1991, the Federal Government introduced the EEAP in order to encourage commercial enterprises in Australia to audit their energy uses. As an incentive to encourage organisations to undertake energy audits the Commonwealth Department of Primary Industries and Energy offered a rebate off the cost of an audit through the program (Harris *et al.* 1996: 1). The Enterprise Energy Audit Program was ended in 1996.

At the State Government level, work has been undertaken to develop codes and guidelines for energy efficiency in government buildings. Consideration has been given to regulating for energy efficiency in buildings. However, in most States further work is still underway to develop new codes and guidelines, establish performance targets and research technologies for achieving improved energy efficiency in building (Building Regulation Review Task Force and Department of Primary Industries and Energy 1991: 1).

Australia is currently under international pressure to cut greenhouse gas emissions. Electricity production accounts for nearly 30% of Australian greenhouse gas emissions (Electricity Supply Association of Australia [ESAA] 1997: 14). It is foreseeable that demand for electricity will continue to rise as the population grows and as governments pursue new industrial development. In December 1992, the Federal government announced the *National Greenhouse Response Strategy* which states that "Australia's response measures should be directed toward the interim planning target of stabilising relevant greenhouse gas emissions based on 1998 levels by the year 2000 and to reducing these emissions by 20% by the year 2005". However, research by Australian Greenhouse Office (AGO 1998) concluded that Australian will not meet that target unless very drastic action is taken.

In 1995, negotiations to establish a protocol which would strengthen the commitments of developed countries to reduced greenhouse gas emissions were set in train. These negotiations were successful in December 1997, where agreement was reached on the text of the Kyoto Protocol. As a result of the Kyoto Protocol, Australia's requirement is only to "limit our greenhouse gas emission in the target period to no more than eight per cent above 1990 levels" (AGO 1998:2).

After the signing of the Kyoto Protocol, the National Greenhouse Strategy (NGS) was developed by the Commonwealth and all State and Territory Governments

(AGO 1998: iii). The NGS outlines a number of strategies for the energy sector which include:

- ***Existing measures*** such as appliance labelling, minimum energy performance of appliances, energy utility initiatives, international benchmarking, and energy information programs; and
- ***Additional measures*** such as energy efficiency standards for commercial buildings, energy performance codes and standards for domestic appliances and commercial equipment, development of energy efficiency technologies and services, manufacture and marketing of low greenhouse gas emission hot water systems, efficiency benchmarking and best practice, and energy information services.

2.1.2 Energy Management

An increasing focus on reducing the cost of energy for business can be expected to produce a much more efficient production and end-use of electricity. "Energy management offers: the best investment available, business competitiveness, personal satisfaction, and a pathway to more sustainable development and assistance with Australia's balance of trade" (Andrews 1991).

Energy management is the long term commitment and support of an organisation's management to improving the energy efficiency of an organisation (Kempski *et al.* 1997: 1). The Department of Primary Industries and Energy [DPIE] (1994a: 2) defined energy management as the process of reducing both the energy costs and the production of greenhouse gases at the same time.

Energy management, in general, means saving wasted energy, choosing the lowest cost energy sources and tariff options, and controlling the time at which energy is used to reduce overall energy costs (Energy Information Centre 1997a).

Energy Victoria (1997a: 9) estimates that most businesses can reduce their annual energy costs by 10-25% through improved energy management.

Energy management programs involve collecting information on energy use, setting targets and priorities for reductions, organising resources to implement changes, and evaluating the results (Anon 1992: 2, DPIE 1994c: 1). Four basic steps in establishing a program are:

1) set energy management policy;

2) conduct an energy audit;

3) formulate the plan of action; and

4) evaluate and maintain the energy management program.

Energy Victoria (1997a: 51) reports that an ideal way of identifying energy management opportunities in an organisation is to conduct an energy audit as part of the process of developing energy management strategy.

2.1.3 Building Energy Auditing

It is normal practice in a company to carry out financial audits so that data may be obtained for management control purposes. In the same way, an energy audit attempts to balance the total input of energy against use.

Building energy audits mean different things to different individuals. Lacking a clear definition, the term "energy audit' has in itself caused confusion. This section reviews the definitions of energy audit and how they are presently being used.

Building energy audits have been defined as; measuring and recording actual energy consumption, at site, of a completed and occupied building (expressed in units of energy, not monetary value); fundamentally for the purpose of reducing and minimising energy usage (New South Wales [NSW] State Projects 1993: 11, Core Government Departments 1997: 19).

However, many studies defined building energy audit as the process of identifying where a building uses energy and identifying energy conservation opportunities. These studies stress that energy audits lead to the identification of specific energy and cost saving measures, which are sometimes referred to as energy conservation opportunities (Thumann 1998: 2, MacDonald and Sharp 1996).

Practically, the purpose of energy audits of commercial buildings is to reduce the amount of energy use by identifying energy conservation opportunities. Energy audits, therefore, identify where both energy and cost savings can be made.

Moreover, the benefits of energy audits also increase asset value and improved building reliability and efficiency (Dobney 1991: 1).

Generally, energy audit procedures need to be organised as a structured series of exercises. There are a number of different approaches to conduct a full building energy audit. However, most methods employ the same fundamental principles and adopt a three-stage process. One suggested approach which has been commonly employed (e.g. Department of Energy 1991, DPIE 1991b: 1-23, Anon 1992: 2, NSW State Projects 1993: 11, DPIE 1994c: 1-19, Energy Victoria 1997a: 52) is as follows.

Stage 1 - Preliminary audit: An audit of historical data

Stage 2 - Walk-through audit: Site surveys

Stage 3 - Detailed audit: Detailed investigation and analysis

2.1.3.1 Stage 1 - Preliminary audit: An audit of historical data

This first stage is divided into two steps: 1) analysis of historical energy records to establish trends; and 2) estimation of energy savings potential.

2.1.3.1.1 Step 1 - Analysis of historical energy records and establishing trends

The first step is to collect historical data, from energy bills, about the building's energy consumption and costs to establish trends and averages. The objectives are: identify the cost and physical quantities of energy use; and determine annual and seasonal trends in energy use and cost.

All energy forms are listed for the current year and converted to a common unit. This will give the relative importance, the unit cost and the total expenditure of each energy form. Then, having determined energy consumption figures and prices per unit of energy for the various fuels being used, examine the suitable alternative fuels and tariffs to arrive at the most cost-effective fuel purchasing agreement.

General trends or patterns in energy use and cost (for both annual and seasonal trends) are established from energy accounts in the past several years if they are available. The trends in energy consumption and cost for a building over a period of time can be represented graphically. These trends are related to changes in seasons, the building and its operations.

2.1.3.1.2 Step 2 - Estimation of energy savings potential

Potential energy savings in buildings are generally estimated by comparing with energy use in other buildings or with a set standard, benchmark or target. To estimate potential energy savings for an overall building, data from step 1 and various building characteristics (such as hours of operation, floor areas, number of occupants etc.) are used to calculate energy consumption indices. These indices are then compared with the energy targets.

Table 2.1 shows the annual base energy indices of different types of buildings in Australia. The values are derived from a number of sources including results from audited and monitored office buildings, Building Owners & Managers Association (BOMA) surveys, discount department store buildings, Northern Territory schools, and computer simulation studies. The indices are the average annual energy consumption levels for the 33% of buildings with the lowest energy consumption and, therefore, represent reasonable targets for low energy building design and operation.

Building Type	Cooling	Heating	Hot water	Interior lighting	Lifts	Mechanical ventilation and pumping
Offices	56	28	1	36	7	14
Schools	42	25	5	17		11
Hospital ward and theatre blocks	208	69	50	78	17	55
Dormitories	36	42	28	22		11
Stores	42	21	3	17		8
Workshops	42	21	5	28		14
Laboratories	83	36	11	39	5	28

TABLE 2.1
Annual Base Energy Indices in kWh/m^2 by building type (adapted from Brown *et al.* 1986: 44)

A study of efficiency of energy audits for public buildings in Tunisia by Abdelhak and Mohamed (1996: 1299) found that the efficiency of energy audits depends much on establishment of models adapted to local conditions. Due to climate differences, climatic records should also be examined to identify any correlations with energy consumption trends (DOE 1996a: 3). Annual energy target values for cooling and heating should be adjusted by multiplying by the values of cooling and heating factors for different locations in Australia shown in Table 2.2.

Location	Cooling Factor	Heating Factor
Melbourne	1.0	1.0
Ballarat	1.0	1.5
Albury	1.3	1.4
Canberra	0.8	1.5
Sydney	1.6	0.4
Adelaide	1.4	0.7
Hobart	0.2	1.4
Launceston	0.3	1.6
Perth	1.9	0.4
Brisbane	2.4	0.1
Townsville	3.2	0
Darwin	4.5	0

TABLE 2.2
Cooling and Heating Factors (Brown *et al.* 1986: 44)

2.1.3.2 Stage 2 - Walk-through audit: Site surveys

The second stage is to undertake a walk-through audit of energy use in the buildings. This stage can be undertaken concurrently with stage 1. Ideally buildings should be tested under operating conditions so the performance can be measured. Therefore, the survey needs to be timed so that it fits in with the organisation's main business hours.

A walk through will indicate: major energy consuming areas; obvious energy waste and inefficiencies; gaps in the metering and reporting of energy use; and priority areas for further investigation of likely inefficient or inappropriate energy technologies. Areas identified by the walk-through energy audit as justifying further investigation will have to be examined in more detail in order to determine the size of avoidable energy losses and the cost of reducing this waste.

2.1.3.3 Stage 3 - Detailed audit: Detailed investigation and analysis

Detailed surveys may incur considerable cost and / or time. It is vital, therefore, to select only those areas that are most likely to yield significant cost savings for a reasonable effort. Detailed energy audits typically cost around 5% of the total energy bill (Smith 1981). This excludes the cost of the works which are recommended to be done. Nevertheless, often on the spot adjustments undertaken during the course of the energy audit can defray some of the cost of the audit.

Stage 3 is carried out in three steps:

Step 1 - Consult the relevant energy efficiency codes and standards

Step 2 - Evaluate potential corrective actions, undertake measurements, estimate savings and cost, estimate implementation cost for feasibility study

Step 3 - Plan the implementation and on-going energy management strategies

2.1.3.3.1 Step 1 - Consult the relevant energy efficiency codes and standards

Consulting the energy efficiency codes and standards (such as Commercial Building Energy Code, Australian Energy Standards, Checklists, etc.) is an effective way to compare the present efficiency of the building with the established standard performance. Commercial Building Energy Code (CBEC) is aimed at establishing design standards for commercial building energy consumption related to the external skin, the lighting and Heating Ventilation and Air Conditioning (HVAC) systems (Ballinger *et al.* 1995: 664, Energy Victoria 1994: iv).

This is followed by a building inspection where common faults described in the code or standard are related to the actual building area. Several inspections, including visits outside normal hours, will be needed to identify faults such as excessive running of equipment, poor maintenance, etc.

2.1.3.3.2 Step 2 – Evaluated potential corrective actions, undertake measurements, estimate savings and cost, estimate implementation cost for feasibility study

Once the causes of inefficiencies in the building area have been identified and options for corrective actions specified, the economic viabilities of these actions should be assessed so that they can be arranged in order of priority. There are four common evaluation techniques to determine the financial merits of each action (DPIE 1994d: 6). They are:

- Average Rate of Return (ARR);
- Payback Period;
- Internal Rate of Return (IRR); and
- Net Present Value (NPV).

In order to evaluate a corrective action the following information must be available: energy consumption of the area being investigated; capital cost of the energy saving proposal; and annual monetary savings arising from the action (Box 2.1).

Box 2.1 Example of information for financial evaluations:

To illustrate the various means of evaluating corrective actions, consider the following example. An aged care organisation identifies its exterior lighting system as a major cause of energy inefficiency, and seeks to rectify the problem. In this example there are 17 existing exterior light fittings, with a 100 Watt incandescent bulb installed in each. Two energy saving actions are considered. The first action is to replace each existing incandescent bulb with a 20 Watt compact fluorescent lamp (CFL). The alternative action is to install two new 150 Watt high pressure sodium (HPS) light fittings to replace the 17 existing light fittings. Both of these actions will provide similar levels of lighting output to the original system. However, the reduced Wattage of both corrective actions will substantially lower electricity consumption. A reduction of 80% will result from the CFL option, while the HPS option will give approximately an 82% decrease. Details of the capital costs, energy consumption, and annual savings of the various options are given in Table 2.3.

Year	Annual Cost for Incandescents ($)	Annual Cost for Energy Saving Options ($)		Annual Cash Flows ($)	
		CFL	HPS	CFL	HPS
Investment	0	391	866 (68 + 798)	-391	-866
End year 1	550 (85 + 465)	93 (0 + 93)	82 (0 + 82)	457	468
End year 2	550 (85 + 465)	93 (0 + 93)	82 (0 + 82)	457	468
End year 3	550 (85 + 465)	484 (391 + 93)	82 (0 + 82)	66	468
End year 4	550 (85 + 465)	93 (0 + 93)	82 (0 + 82)	457	468
End year 5	550 (85 + 465)	484 (391 + 93)	150 (68 + 82)	457	400
End year 6	550 (85 + 465)	93 (0 + 93)	82 (0 + 82)	457	468
End year 7	550 (85 + 465)	484 (391 + 93)	82 (0 + 82)	66	468
End year 8	533 (68 + 465)	93 (0 + 93)	82 (0 + 82)	440	451

TABLE 2.3

Comparison of capital and energy costs of 17 incandescent bulbs of 100 W, 17 compact fluorescent lamps (CFL) of 20 W, and two high pressure sodium lamps (HPS) of 150 W.

Calculations assume: lighting used 10 hours per day (3,650 hours of use per year); costs of $0.07492 per kWh of electricity (current Tasmanian prices); costs of $1 for each incandescent lamp, $23 for each CFL lamp, and $34 for each HPS lamp (current Tasmanian prices); a cost of $399 for each HPS fitting (current Tasmanian prices); and lives of 750 hours for each 100 Watt incandescent lamp, 7,500 hours for each 20 Watt compact fluorescent lamp, and 15,000 hours for each 150 Watt high pressure sodium lamp (Energy Information Centre 1997c). It should be noted that the labour cost for lamp changing is not included in this example.

Annual costs for the existing light system consist of replacing globes at each fitting an average of just under five times per year plus electricity consumption of $465. Hence for the first seven years, the cost is 17 fittings × 5 globes at $1 each = $85, but in the eighth year, the cost will be 17 fittings × 4 globes at $1 each = $68. Costs for the CFL action comprise capital costs of 17 lamps at $23 each ($391) every second year plus annual electricity costs of 20% those of incandescent bulbs. For the HPS option, costs consist of two lamps at $34 each ($68) every fourth year plus annual electricity costs of 17.65% those of incandescent bulbs. In addition, an initial capital cost of $798 for the two fittings is incurred when selecting the HPS option. From these data, annual cash flows can be calculated by subtracting the annual costs associated with each energy saving option from the annual costs arising from the existing situation. Financial evaluation calculations of Average Rate of Return, Payback Period, Internal Rate of Return, and Net Present Value can then be conducted.

2.1.3.3.2.1 Average Rate of Return (ARR)

The Average Rate of Return (ARR) represents the ratio of **average annual cash flows** (or average annual return on investment) to the **initial cost of the asset** (or purchase of asset). The ARR is simply calculated as:

$$\textbf{ARR} = \frac{\textbf{Average annual cash flows}}{\textbf{Initial cost of the asset}}$$

However, ARR only measures average cash flows as a percentage of the total cost of the asset in isolation. It does not measure whether the funds are used to the best effect, in contrast to IRR and NPV. See Box 2.2 for calculations.

Box 2.2 Example of Average Rate of Return Calculations:

In the hypothetical aged care organisation (see Table 2.3), the average rate of return in each year is always greater for the CFL than the HPS action (Table 2.4). If the benchmark for returns on investments under Average Rate of Return has been set at 55%, the HPS action does not meet the investment benchmark while the CFL action does. Hence, the CFL action would be selected over the HPS action if this evaluation technique was the only one used.

Year	ARR for CFL	ARR for HPS
End year 1	117% (457 ÷ 391)	54% (468 ÷ 866)
End year 2	117% (457 ÷ 391)	54% (468 ÷ 866)
End year 3	84% (327 ÷ 391)	54% (468 ÷ 866)
End year 4	92% (359 ÷ 391)	54% (468 ÷ 866)
End year 5	77% (301 ÷ 391)	52% (454 ÷ 866)
End year 6	84% (327 ÷ 391)	53% (457 ÷ 866)
End year 7	74% (289 ÷ 391)	53% (458 ÷ 866)
End year 8	79% (308 ÷ 391)	53% (457 ÷ 866)

TABLE 2.4
Examples of ARR calculations (using data from Table 2.3)

2.1.3.3.2.2 Payback Period

The payback period is a method of approximating the economic worth of a project. The payback period is the time required to recover the capital investment from the savings (Thumann 1998: 68).

The payback period is simply computed as:

$$\textbf{Payback Period} = \frac{\textbf{Initial cost of the asset}}{\textbf{Annual cash flows}}$$

Most energy audit recommendations are classified by using the payback period as follows (DPIE 1994a: 3):

- immediate and short term actions
- medium and long term actions.

Immediate and short term actions are measures with a payback of less than one year. These include energy measures such as housekeeping, calibration of controls, reducing excessive light levels, turning lights off in unoccupied areas and reducing equipment running hours. These tend to have little or no capital cost and have immediate running cost savings.

Medium and long term actions have longer payback periods. These include such measures as fuel substitution, upgrading control systems, reflective film on glass, and upgrading of lighting systems.

The payback period provides some insight into the risk of an investment as the quicker the payback of funds the less risky the action. Nevertheless, the payback period method ignores all savings subsequent to the payback years. Hence the longer-term benefits of actions that have long life potential are not recognised. Not only does it fail to consider cash flows after the payback period, it also takes no account of the magnitude and timing of cash flows during the payback period. Therefore, the payback period is not a good benchmark of profitability of an action (DPIE 1994d: 7). See Box 2.3 for calculations.

Box 2.3 Example of Payback Period Calculations:

Calculations of the payback period for the CFL and HPS actions, using data from Table 2.3 are:

- approximately 10 months ($391 ÷ $457/year = 0.86 years) for the CFL action; and
- approximately 1 year and 10 months ($866 ÷ $468/year = 1.85 years) for the HPS action.

Hence, the CFL investment would be selected over the HPS investment because of its shorter payback period.

2.1.3.3.2.3 Internal Rate of Return (IRR)

The Internal Rate of Return (IRR) is a measure of profitability of an action and indicates whether the funds to be spent on energy saving investments could be better deployed elsewhere in the business, or by placing the funds in an interest bearing deposit. The IRR is calculate as:

$$\mathbf{P} = \sum_{i=1}^{n} \left[\frac{\mathbf{F_i}}{(1 + \mathbf{r})^{i}} \right]$$

where **n** is number of years, **r** represents the ***internal rate of return (IRR)***, $\mathbf{F_i}$ is the annual cash flow at the end of the year **i,** and **P** is present value of net cash flow from the investment.

To find the value of '**r**' in this formula requires the use of one of the following three processes:

- using an established computer program (such as EXCEL or LOTUS 1-2-3);
- using a financial calculator which incorporates internal rate of return functions; or
- using the basic trial and error method.

If an action's IRR is greater than the rate of return from investments in other areas it can be accepted. While if it falls below the rate of return from investments in other areas the proposed action should be rejected.

It is important to note that this technique requires a basic understanding of financial mathematics beyond the scope of this review. For worked examples of the basic trial and error method see DPIE (1994d: 19-22). See Box 2.4 for calculations.

Box 2.4 Example of Internal Rate of Return Calculations:

For the hypothetical aged care organisation (see Table 2.3), the internal rate of return in each year is always greater for the CFL than the HPS action (Table 2.5). If the rate of return from investments in other areas is 10%, the CFL action will be accepted at all periods because this action's internal rates of return in all years are higher than 10%. In contrast, the HPS action's internal rates of return in year 1 is negative values. This indicates that returns on investment are less than capital costs during this period. However, the HPS action starts to make a profit and also meet the 10% standard three years after the initial investment. However, the IRR for the CFL action from year 3 to year 8 is still higher than the IRR for the HPS action throughout this period. This would result in the HPS action being rejected and the CFL action being accepted.

Year	CFL	IRR Calculations and formulas in MS Excel for CFL
End year 1	17%	=IRR({-391;457})
End year 2	81%	=IRR({-391;457;457})
End year 3	85%	=IRR({-391;457;457;66})
End year 4	96%	=IRR({-391;457;457;66;457})
End year 5	97%	=IRR({-391;457;457;66;457;66})
End year 6	99%	=IRR({-391;457;457;66;457;66;457})
End year 7	99%	=IRR({-391;457;457;66;457;66;457;66})
End year 8	100%	=IRR({-391;457;457;66;457;66;457;66;440})
Year	**HPS**	**IRR Calculations and formulas in MS Excel for HPS**
End year 1	-46%	=IRR({-866;468})
End year 2	5%	=IRR({-866;468;468})
End year 3	29%	=IRR({-866;468;468;468})
End year 4	40%	=IRR({-866;468;468;468;468})
End year 5	45%	=IRR({-866;468;468;468;468;400})
End year 6	48%	=IRR({-866;468;468;468;468;400;468})
End year 7	50%	=IRR({-866;468;468;468;468;400;468;468})
End year 8	52%	=IRR({-866;468;468;468;468;400;468;468;451})

TABLE 2.5

Examples of the IRR calculations (IRR are calculated from data in Table 2.3)

2.1.3.3.2.4 Net Present Value (NPV)

The Net Present Value (NPV) calculation, similar to that for IRR, considers the magnitude and timing of future cash flows and by itself is a good indicator of an investment's profitability. However, in calculating NPV, all future net cash flows are discounted back to their present value to take account of their erosion by the social time preference rate; a factor not considered when calculating IRR.

As was the situation for the IRR calculation, this technique requires a basic understanding of financial mathematics. Computer programs (such as EXCEL or

LOTUS 1-2-3) and financial calculators have NPV formula built in, which makes the process of calculation relatively straightforward.

The NPV is calculated as:

$$\textbf{NPV} = \sum_{i=1}^{n} \left[\frac{\mathbf{F_i}}{(\mathbf{1+r})^{\mathbf{i}}} \right] - (\textbf{ Initial cost of the asset })$$

where **n** is number of years, **r** is the annual discount rate, and $\mathbf{F_i}$ is the annual cash flow at the end of year **i**.

A positive NPV indicates a net benefit to the investor while a negative result indicates a net loss. See Box 2.5 for calculations.

Box 2.5 Example of Net Present Value Calculations:

For the hypothetical aged care organisation (see Table 2.3), the positive NPVs in all years for the CFL action (Table 2.6) indicate this investment provides consistent profits even when the annual discount rate is as high as 5%. In contrast, the HPS action's net present value in year 1 is a negative value. However, the HPS action starts making profits against an annual discount rate of 5% two years after the initial capital outlay. Nevertheless, the NPVs for the CFL action from year 2 to year 4 are still higher than the NPV values for the HPS action. However, the NPV of HPS action overtakes the NPV of CFL action after five years, indicating that the HPS action is the better long-term investment.

Year	CFL	NPV (5%) Calculations and formulas in MS Excel for CFL
End year 1	$42.13	=NPV(5%,-391,457)
End year 2	$436.91	=NPV(5%,-391,457,457)
End year 3	$491.20	=NPV(5%,-391,457,457,66)
End year 4	$849.28	=NPV(5%,-391,457,457,66,457)
End year 5	$898.53	=NPV(5%,-391,457,457,66,457,66)
End year 6	$1223.31	=NPV(5%,-391,457,457,66,457,66,457)
End year 7	$1267.98	=NPV(5%,-391,457,457,66,457,66,457,66)
End year 8	$1551.61	=NPV(5%,-391,457,457,66,457,66,457,66,440)

Year	HPS	NPV (5%) Calculations and formulas in MS Excel for HPS
End year 1	-$400.27	=NPV(5%,-866,468)
End year 2	$4.00	=NPV(5%,-866,468,468)
End year 3	$389.03	=NPV(5%,-866,468,468,468)
End year 4	$755.72	=NPV(5%,-866,468,468,468,468)
End year 5	$1054.21	=NPV(5%,-866,468,468,468,468,400)
End year 6	$1386.80	=NPV(5%,-866,468,468,468,468,400,468)
End year 7	$1703.56	=NPV(5%,-866,468,468,468,468,400,468,468)
End year 8	$1994.28	=NPV(5%,-866,468,468,468,468,400,468,468,451)

TABLE 2.6
Examples of the NPV calculations (based on data in Table 2.3 and assuming a 5% annual discount rate)

2.1.3.3.3 Step – 3 Plan the implementation and on-going energy management strategies

Existing older buildings exhibit the most severe problems of excessively high energy consumption, and need effective renovations and system retrofitting. In contrast, new building construction, following more strict building codes for energy conservation, and using energy efficient systems along with well established energy conservation techniques, contributes to the overall effort of energy saving. However, the extent of this contribution depends on the strength of regulations for reducing the use of energy in new buildings.

Research by Lincolne Scott Australia Pty Ltd and AT Cocks and Partners Pty Ltd [LSA&ATCP] (1996: 1) found that renovation has become the most significant component of construction activity in the Australian commercial building sector. Energy efficiency must be considered and implemented in the renovation process to have any real impact on the overall energy consumption of the commercial building sector for it is at this stage of the building life cycle that the greatest opportunity for cost effective change exists. Unfortunately, the research (LSA&ATCP 1996: 1) also found that energy consumption issues are still not currently a primary consideration in much of the renovation work being undertaken in this country.

2.1.4 Factors in a Successful Energy Management and Energy Audit Program

Many factors are involved in a successful energy management and energy audit program. The Department of Primary Industries and Energy [DPIE] (1994b: 2) recommends the three factors for the successful program. They are:

- the full support of people in an organisation, from senior management to junior staff;
- an effective reporting system which makes organisations accountable for the energy they use; and
- the provision of adequate funds and staff resources.

The first and most important factor is the cooperation of people within the organisation itself. For the program to be meaningful, it will be necessary to discuss the energy management and auditing process with all staff, both senior and general, and obtain their cooperation in data gathering. Employees are often a most valuable source of information about waste and inefficiencies (Energy Victoria 1997a: 51).

Audits and surveys produce valuable information for the management of any business. However, the maximum benefits are only realised when the available savings measures are implemented. An energy auditor can only make recommendations for actions leading to energy and cost savings. It is up to the organisation concerned to take the decision to adopt the recommendations and, where necessary, invest in energy management measures.

A study in the United Kingdom by Doggart and Grant (1997: 145) found that cost savings of between 10% and 30% were almost always identified by energy audits which could be made at little or no capital cost by resetting the energy related controls of buildings to optimum setting. Nevertheless, in spite of these benefits, practically none of the organisations changed their controls. Moreover, many organisations showed a defensive attitude and did not welcome the information provided to energy auditors.

A report from Australian Bureau of Agricultural and Resource Economics (Harris *et al.* 1996: 5) showed that only 17 percent of Australian firms had implemented all of the energy audit recommendations, while 8 percent had implemented none of them. Many firms did not implement recommendations because they were apparently uneconomic. However, 60 percent of firms had implemented some energy audit recommendations, but not all of their audit recommendations. Fifteen percent did not provide enough information to be included in the analysis.

The report (Harris *et al.* 1996: 5) also found that there were several problems in the way energy auditors were specifying savings, and that the cost of recommended measures were making management decisions to implement recommendations difficult or impossible. There was for instance, a wide variability in the quality of information supplied by energy auditors about specific problems. This included the provision of unclear information on the amount of energy savings and costs of implementation and the grouping together of several recommendations with different energy savings potential and implementation costs.

Before an organisation commits itself to an energy reduction investment program, it is important to apply exactly the same evaluations to reducing its energy consumption as it applies to all other investments (Energy Victoria 1997a: 43).

2.2 Energy Auditing In the Health Sector Including Aged Care Organisations

2.2.1 Introduction

Commercial buildings can be classified in a number of ways depending on their function and size. The Australian Bureau of Statistics adopted the following format categories in the development of the Building Energy Code of Australia: 1) large office; 2) small office; 3) large retail; 4) small retail; 5) health; 6) education; and 7) accommodation (LSA & ATCP 1996: 26).

As stated in chapter 1, buildings in the health sector require particular attention because they have high levels of energy consumption compared to other commercial buildings. Moreover, a report by U.S. Department of Health and Human Services [USDHHS] (1984: 1) showed that since the oil embargo of 1973, expenditure on energy in the health care industry had risen dramatically from 0.5% to between three and eight percent of its total budget. This does not indicate that the health care sectors are consciously energy inefficient. It simply means that most health care buildings were built prior to 1973 when energy costs were low. It was estimated (in 1983) that more than 90 percent of the US existing hospitals were built and/or designed prior to 1973-74 and thus were largely energy inefficient by today's standards (Hunt 1983: vi).

As energy bills continue to occupy greater and greater portions of the budgets, health care facility managers will have to plan for and implement effective energy cost saving programs.

2.2.2 Energy auditing in health sector

In the classification of commercial buildings used by the Australian Bureau of Statistics, the health sector encompasses public and private hospitals, large health clinics, and convalescent homes including old people's homes (LSA & ATCP 1996: 26).

1) Hospitals are large health care buildings with patient rooms, which provide full health care services and examinations, and operate on a 24-hour basis.

2) Clinics are smaller health care buildings without patient rooms, which provide basic health care services and examinations, with a limited working hour schedule in comparison to hospitals.

3) Old people's homes and convalescent homes are smaller health care buildings with patient rooms, which provide basic health care services on a 24-hour basis.

Providing for an acceptable environment for appropriate patient care is a major part of the energy consumption of a health care building. Heating, cooling, domestic hot water and lighting systems for occupant needs are generally responsible for approximately 80% of energy consumed (USDHHS 1984: 1).

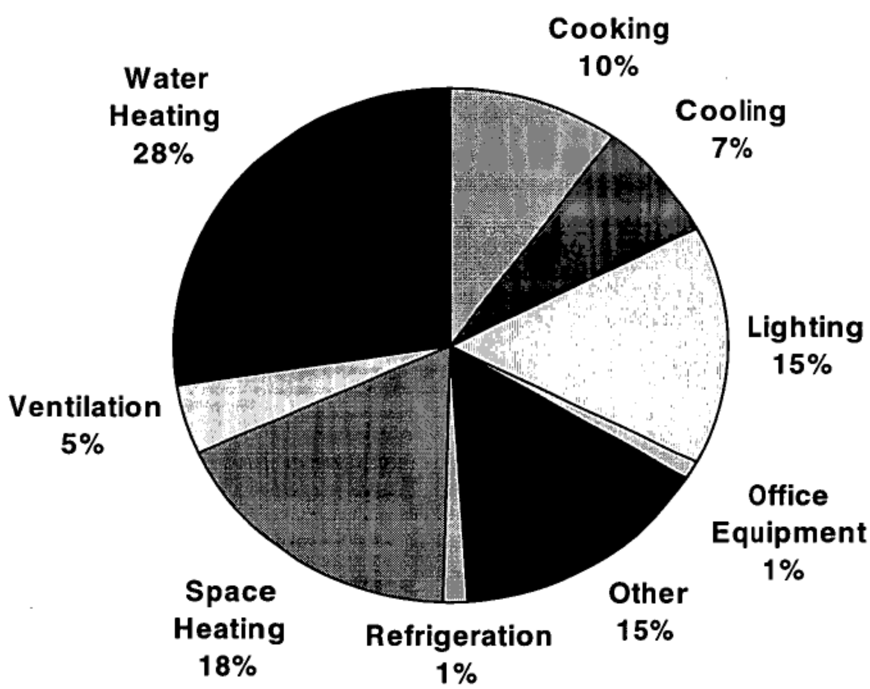


FIGURE 2.1
End-Use Intensities of the average annual Energy Profile of US Health Care Buildings (adapted from EIA 1994: 14)

Majority end-use intensities in Figure 2.1 are in the areas of water heating (equal to 189 kWh/m^2 or 28%), space heating (equal to 121 kWh/m^2 or 18%), and lighting (equal to 104 kWh/m^2 or 15%). These areas are the prime considerations for energy saving in the health sector. The total energy requirement for U.S. health care buildings is around 689 kWh/m^2. This average energy profile will vary due to climate differences in different locations (DOE 1997c: 24).

In UK, the average annual energy consumption for old people's homes (393 kWh/m^2) (DOE 1996a: 3) is similar to that for hospitals (407 kWh/m^2), but greater than for clinics (275 kWh/m^2) in Greece (Santamouris *et al.* 1994: 294). This is also higher than the 273 kWh/m^2 in hotel buildings, 187 kWh/m^2 in office buildings, 152 kWh/m^2 in commercial buildings, and 92 kWh/m^2 in school buildings (Santamouris *et al.* 1996: 67). This relatively high energy consumption in old people's homes and hospitals in comparison with other types of buildings largely results from their 24-hour operations. In particular, continuous use of heating and cooling equipment in order to maintain satisfactory thermal comfort and indoor air quality levels for the patients, and the continuous use of artificial lighting contribute to this. As they are in operation 24 hours a day, all year round; they require sophisticated backup systems in case of utility shutdowns; and they use large quantities of outside air to combat odours and to dilute micro-organisms (Santamouris *et al.* 1994: 295, Hunt 1983:3, USDHHS 1984:1).

However, the total energy requirement for the UK and Greece health care buildings such as hospitals, old people's homes, and clinics (407, 393, and 275 kWh/m^2) are approximately half that for the U.S. health care buildings (689 kWh/m^2). This could be because the UK and Greece have different climate, building technologies, and/or building regulations to the USA. The differences like these in many countries around the world will be investigate in the next chapter (Chapter 3: Overseas Best Practice Energy Standards).

Energy surveys in 52 UK old people's homes by DOE (1996a: 3) found that 80% of the homes in the survey were built before the 1960s. Old aged care buildings were not always built rationally and with modern day structural and fire codes, major modification or renewal may be required. Many old people's homes, especially in the charitable sector, are old buildings (Salter 1996: 148). Renovations therefore, provide an opportunity for the implementation of energy efficiency.

It appears that energy consumption can vary significantly with the category and the function of the building, the type of construction, location, the deployed heating, cooling and lighting system (type, number, size, efficiency), and the other energy consuming equipment. However, there are still several scenarios for reducing the energy consumption in all types of building.

In health care buildings, the potential for energy savings are very high. A recent study by the Australian Bureau of Agricultural and Resource Economics (ABARE) reported that within the community services sector, health services are estimated to have the highest potential for energy savings (Harris *et al.* 1996: 17). Furthermore, a report from an Australian survey by LSA & ATCP (1996: 5,48) found that the highest level of consideration of energy efficiency in renovation identified by building function was also in the health sector.

As a result of the 24-hour operations in hospitals and old people's homes, the payback period for energy saving investments will also be shorter than for schools or office buildings that have normal hours of operation.

2.2.3 Energy auditing in aged care organisations

Energy management in aged care organisations aims to ensure that energy use and energy cost are as low as possible while standards of comfort and service are maintained or improved. Energy audits in aged care buildings are conducted using a similar method to other commercial buildings as described in section 2.1.3.

Energy use in an aged care building may be due to a number of variables (Figure 2.2) (Isaacs *et al.* 1995: 8). The external environment is often presented only by temperature such as heating degree days, but other climatic factors such as sunlight, cloud, and relative humidity are also important.

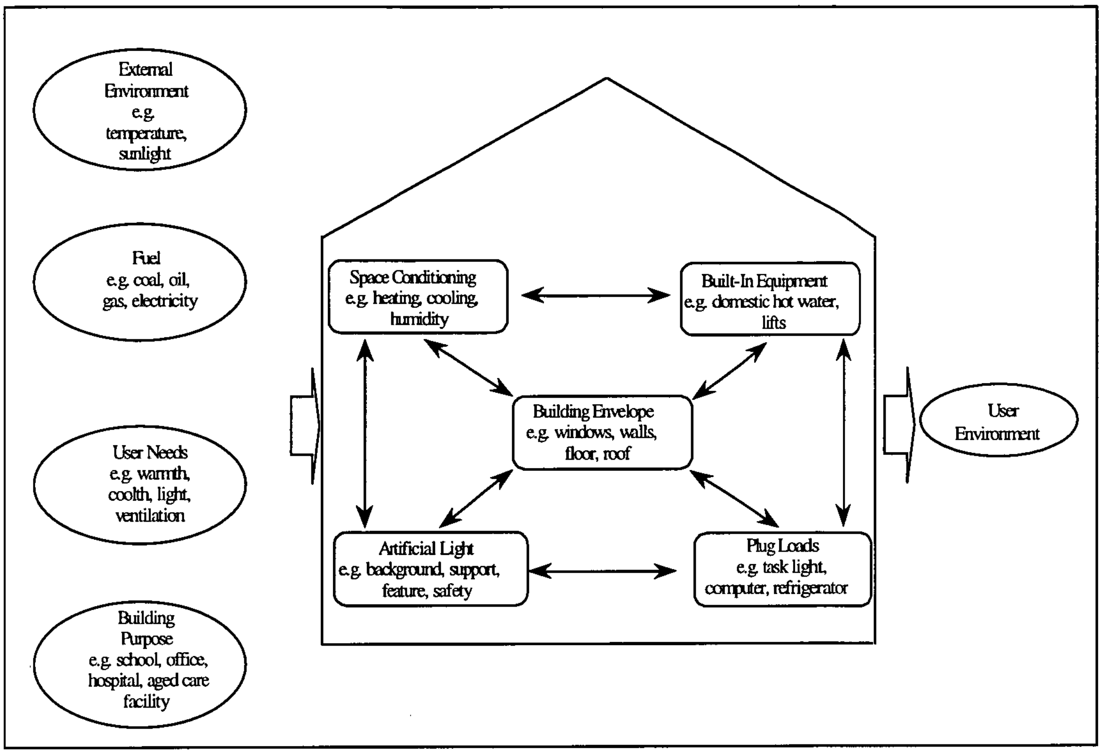


FIGURE 2.2
Building Energy Use Model (Isaacs *et al.* 1995: 9)

Energy consumption in buildings generally correlates reasonable well with the average degree days for the location (NSW State Projects 1993: 327) (Figure 2.3). Degree day is a measure of how hot or cold a location was over a period of time, relative to a base temperature. In Europe, the base temperature used is normally 15.5°C (60°F), while in USA it is 18.3°C (65°F) (DOE 1993: 12, EIA 1998: 383, 387). Heating degree days are the summation of the product of the difference in temperature between the daily average outdoor temperature and base temperature multiplied by the number of days the outdoor temperature is below 15.5°C or 18.3°C (Thumann and Mehta 1997, http://vesma.com/ddd/whatthey.htm: 16/2/2000).

The graph of energy consumption against the degree days can also show the energy performance of a building. A building with better insulation would have a less steep slope or a lower y-intercept than a building with poor insulation because energy consumption would be lower for any given degree day (DOE 1993: 12).

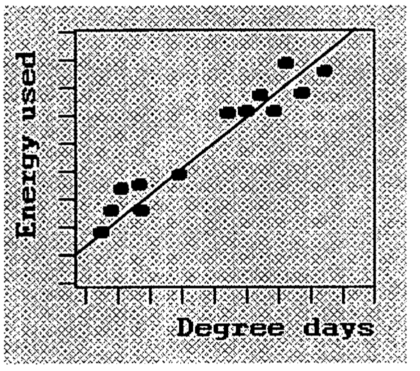


FIGURE 2.3
Weather dependence of energy use (http://vesma.com/ddd/ddexpl-1.htm: 16/2/2000)

Fuel supply varies from location to location as do prices. User needs can be established for example by building controls, occupational safety and health legislation, as well as by the actions of the users, e.g. opening a window, turning on the lights, etc. The building purpose may be defined at the design stage but can change with time.

The five factors with energy impacts in Figure 2.2 could be considered in separation, but in practice they interact (Isaacs *et al.* 1995: 10). The links between the energy using factors show that there are flows with energy consequences in both directions. These interactions are not necessarily clear, but can lead to increased (or decreased) energy use.

The next section attempts to provide a background information and services in old people's homes.

Many older Australians live independently and in their own homes. However, approximately one in five Australian people over the age of 80 and as many as one in 20 people over the age of 65 have some forms of dementia and live in a residential aged care facility, i.e. a hostel or nursing home (Commonwealth Department of Health and Family Services 1998: 3, Aged and Community Care Division [ACCD] 1998: 1).

An aged care organisation is a place for elderly people who are too frail to live independently in their own home. Historically there have been two options in aged care accommodation: hostel and nursing home (Orme and Australian Law Reform Commission [ALRC] 1994). However, according to the Aged and Community Care

Division (1998: 7), recent reforms to residential aged care facilities have introduced a new classification called 'specified care and services'. There are three categories of specified care and services. These are: accommodation services; hostel level care services; and nursing home level care services (ACCD 1998: 7).

- **Accommodation Services**

  Accommodation services provide basic accommodation and related services such as: furnishings and bedding; general laundry and cleaning services; maintenance of buildings and grounds; and the provision of staff continuously on call to provide emergency assistance (ACCD 1998: 8). Accommodation residents usually live in "apartment-type units", this type of service first evolved in the Netherlands and Scandinavia (Valins and Scott 1996: 65-66).

- **Hostel Level Care Services**

  Hostel level care services generally provide accommodation and personal care. Hostel residents are able to provide a level of self care and usually live in rooms similar to a hotel room, i.e. single rooms with a single bed with bath but no pantry or kitchen area (Orme and ALRC 1994: 16). The services include assistance with the activities of daily living, such as washing, bathing, toileting, eating and dressing; with mobility and communication; meals including special diets; and for people who are confused, including people with dementia (ACCD 1998: 8). Hostels also provide occasional nursing care when required, rehabilitation services and individual attention (Orme and ALRC 1994: 16).

- **Nursing Home Level Care Services.**

  Nursing home level care services have tended to care for people with a greater degree of frailty. Residents in nursing homes are usually too frail or too confused (or both) to be able to care for themselves except in very basic tasks. The residents require higher levels of care and are often in need of continuous nursing care. Accommodation in nursing homes is similar to a small ward in a hospital (Horwood 1993: 29). Nursing home care provides assistance to perform daily tasks like eating, bathing, toileting, dressing, and moving around; and other support services, such as a bed, cleaning, laundry services, and meals (Orme and ALRC 1994: 12). The services may include: specialised furnishings and equipment items, such as those used to assist with mobility and maintaining continence; basic medical and pharmaceutical supplies and equipment; nursing procedures; administration of/help with administering medication; therapy services; and oxygen and oxygen equipment on a short term or episodic basis (ACCD 1998: 8).

The next section attempts to provide a comprehensive information source for common technologies employed in old people's homes, and focuses on the use of energy efficiency principles to reduce energy consumption and cost in aged care buildings. Aged care institutions consist of accommodation, nursing homes, hostels, kitchens, laundries, libraries, etc. Hence they differ from other commercial buildings in their energy use profiles due to their unique characters and operations. The technologies are reviewed in six areas as follows: 1) hot water; 2) heating, ventilation and air conditioning; 3) lighting; 4) building fabric; 5) kitchen; and 6) laundry. It should be noted that the information provided in this section is focused on energy efficient technologies for temperate climates (i.e. Tasmania) in Australia.

2.2.3.1 Hot water

In old people's homes, hot water is likely to be a major energy user, as many areas in the homes require hot water at all times. Choosing the most appropriate system and the selection of the energy source depends on the circumstances and can considerably lower the hot water costs.

There are two kinds of systems for supply of domestic hot water in commercial buildings (Energy Victoria 1994: 35). These are: storage water heaters, which heat and store water in an insulated tank ready for use; and continuous flow (instantaneous) water heaters, which heat water only as it is required.

Continuous flow water heaters must have high rates of heat input to raise the flow of water to the require temperature during only one pass through the heater. The energy input rates power of storage water heaters can be smaller since the stored hot water provides a time buffer (Australian and New Zealand Environment Council [ANZEC] 1991: 2).

Storage water heaters are therefore the commonly used hot water systems in old people's homes since they are generally installed where there is a large hot water requirement at many points (Energy Victoria 1994: 35). They usually operate on electricity, natural gas, liquefied petroleum gas (LPG), or solar energy.

The Australian and New Zealand Environment Council (1991: 5) pointed out that gas water heaters are more costly to buy and install than electric water heaters. They are also less efficient in converting the input energy to useful hot water, since there are energy losses associated with combustion and, in many designs, with the pilot flame (ANZEC 1991: 5). Nevertheless, the higher initial cost and lower efficiency is more than out weighed by lower gas costs because natural gas energy is usually much cheaper to run. For example, only about a third of the cost of electrical energy in Victoria (Energy Victoria 1996: 17).

The level of carbon dioxide (CO_2) emissions associated with each water heater depends on the type of energy used, its efficiency, and the amount of hot water it produces (ANZEC 1991: v). When fossil fuels are burnt to generate the electricity used to heat water, the fossil fuel combustion can cause an increase in CO_2 emissions. As a result, electricity derived from fossil fuel combustion is by far the most CO_2 intensive means of heating water. Conventional gas, electric boosted solar and electric heat pump units are all similar in their CO_2 intensity. Gas boosted solar and gas heat pump units are the least CO_2 intensive (ANZEC 1991: v).

In areas where natural gas is not available, such as Tasmania, LPG can be used. LPG is more expensive than natural gas, the running costs average around one and a half to two times the price of natural gas (Energy Victoria 1997d: 4). Hence the price should be checked locally. Sometimes it is cheaper to operate electric water heaters. Generally, the purchase price of LPG is subject to direct negotiations between supplier and customer. The factors which influence the cost are: the transportation costs between the supplier and the homes; the size of the storage tanks on site and the size of the load delivered each time; and whether the storage tanks are owned by the consumer or the supplier (NSW State Projects 1993: 191,202).

Heat pump water heaters are a new high efficiency form of water heating that operate on electricity. They are generally two or three times more efficient than conventional electric water heaters due to the heat extraction from the atmosphere using a refrigerant gas and a compressor (Sezgen and Koomey 1995: 12). Heat pump water heaters offer an energy-efficient method of heating domestic water for commercial buildings. However, for models currently on the Australian market, they are the most expensive of all to purchase and install (Energy Victoria 1997d: 6, ANZEC 1991: 9). The competitiveness of a heat pump water heater versus other forms of commercial water heating depends on the electricity to fuel price ratio, hot water requirements, the incremental capital cost of the heat pump water heater, and the efficiencies of the competing technologies (Cane and Clemes 1996: 10).

Solar water heaters are generally the cheapest systems to run but have relatively high purchase costs (Energy Victoria 1997d: 3). A study of low energy housing for the elderly in New Zealand (http://194.17286/register/data-ee/cce00636.htm: 16/01/2000) found that solar water heaters gave hot water electricity savings of 40% with a payback between 11 and 18 year (depends on their electricity tariffs). However, Todd (1994b) indicated that a solar water heater takes about seven to twelve years to pay back the capital costs in Tasmania. Installation is also more expensive; the most common types have both tank and the collector installed on the roof, requiring longer pipe and cable runs, and sometimes reinforcement of the roof structure (ANZEC 1991:7).

There are two main types of storage hot water systems that have been used, these are: pumped circulating hot water systems; and storage hot water systems without pumps (Energy Victoria 1997d: 2).

Pumped circulating hot water systems have a big single plant or boiler room where all water is heated then circulated inside hot water pipes throughout a building. These systems are found in some old people's homes, particularly in nursing home areas that require hot water at all times. However, these systems are best avoided as the heat losses from the hot water pipes may represent over half the heating energy (Horwood 1993: 61). It is much better practice to have many small hot water systems scattered throughout the facilities (Horwood 1993: 61). This reduces the hot water pipe losses and the need to use a pump. Consequently, Energy Victoria (1997d) recommends that pipe runs are short and all parts of the system are well insulated.

Also, the first two metres of hot water pipes leading from the hot water system should have closed cell rubber insulation to prevent heat loss.

Storage hot water systems without a pump have many small storage hot water heaters scattered around major hot water usage areas in a building. There are two main types of these storage hot water heaters that have been used, these are: mains pressure system; and low pressure system (Energy Victoria 1997d: 2).

- Mains pressure system, hot water is delivered at a similar pressure and flow rate as the cold water. This means that more than one outlet can be turned on without affecting supply pressure.

- Low pressure system, hot water is delivered at lower pressure than main pressure units, and are also known as "gravity feed" or "constant pressure" systems. The storage tank is normally located in the roof space, and the pressure depends on the vertical height between the tank and point of use. This means less hot water (compared to main pressure system) is delivered in a given period of time and also mean less energy is required to heat the water.

Old people's homes as well as hospitals are at risk from *Legionella* contamination. Legionellosis is an acute bacterial disease caused by *Legionella pneumophilla*, commonly found in water and most often affects patients who are elderly (DOE 1997b: 13). As contamination of *Legionella* is associated with hot water temperature (States *et al.* 1998: 122), hot water storage thermostats should be set to the lowest useable temperature for reasons of energy saving and control of *Legionella*. The temperature setting at 60°C is recommended by the Health and Safety Executive (1991) to eliminate the risk of *Legionella*. Nevertheless, this temperature setting still can present a risk of scalding to the elderly. Hence it is also recommended that thermostatically controlled mixing valves are installed (DOE 1996c: 3). This allows the hot water system to operate at above 60°C while allowing hot water at lower temperatures to be delivered at the tap, where 43°C is recommended to avoid the risk of scalding (DOE 1996c: 3).

Low flow shower heads or flow restricting valves are another energy saving measures that can be installed in old people's homes to reduce the amount of hot and cold water delivered to existing shower heads (Energy Victoria 1997d).

A study of Batley Hall nursing and residential home in UK (DOE 1997a: 3) found that energy efficiency measures in an old people's home in some cases have other benefits.

> *"One elderly resident used to leave a hot water tap running, emptying the hot water tank and leaving no water for other residents. To solve this problem the owners installed a tap with a timed infrared sensor control. Now the resident moves her hand in front of the sensor to switch the tap on. It then switches off automatically, leaving enough hot water for other residents and saving energy at the same time* (DOE 1997a: 3)."

2.2.3.2 Heating, Ventilation and Air Conditioning

HVAC is the acronym for Heating, Ventilation and Air-Conditioning system used in buildings (Energy Victoria 1994: 31). The HVAC systems are essentially installed in aged care buildings to provide for residential thermal comfort, health and safety. These systems also provide fresh and filtered air, and may be designed to adjust the humidity level of a building interior (Energy Victoria 1994: 31).

It is desirable for the designer of HVAC systems to carefully examine the parameters influencing thermal comfort which have major impacts on energy demand before choosing the best possible systems for the building (Clifford 1990: 1). These parameters encompass thermal quality of buildings, climate, and the purpose for which the building is used (Haas *et al.* 1998: 195). The thermal quality of aged care buildings is affected by insulation levels and airtightness. Climate influences energy consumption for thermal comfort via temperature related changes to the heating or cooling degree days, as well as the desire to regulate internal relative humidity. The purpose for which the building is used influences energy consumption by affecting hours of operation and the number and type of occupants. A study by Haas *et al.* (1998: 195) indicates that building occupants are the most important issues with respect to energy consumption in buildings. Elderly residents require a higher degree of thermal comfort and ventilation than occupants of most other types of commercial buildings do, for instances, occupants in office, school, and hotel buildings.

The nursing home residents are usually frail and require a high degree of thermal comfort, and the areas are occupied twenty four hours a day and require adequate ventilation. However, hostel rooms are frequently unoccupied for long periods in a day, and the residents may be considered independent from other units, it is desirable to have individually controlled forms of heating for each unit rather than have all units heated together (Horwood 1993: 44,52).

Over the past few years, the so-called "sick building" syndrome has attracted a lot of attention. It has been observed in old and new buildings, as a result of the contamination of indoor air from building materials, human activities, outdoor pollutants, inadequate ventilation, and malfunction of heating and cooling systems (Argiriou *et al.* 1994: 385). Consequently, ventilation is important as a health requirement in all buildings (Dumont and Makohon 1997: 14).

Thermal comfort and indoor air quality of the buildings is having a direct impact on energy consumption. As a result, energy demand to produce these comfort conditions has been ever increasing over the years (Clifford 1990: 1) and the cost of energy used in HVAC systems has become a more substantial component of building running costs. Therefore, existing HVAC systems in aged care organisations must be re-evaluated and, when required, redesigned to bring them up to acceptable levels of energy efficiency. The biggest improvement that can be made to heating systems often involves upgrading control systems. Typically, upgrading controls can save between 15% and 35% of the heating bills, depending upon the existing level of comfort and control (DOE 1996b: 3).

There are two types of HVAC systems currently available, which are 1) centralised plant, and 2) packaged plant (Energy Victoria 1994: 31-32). Centralised plant has the plant centralised in one area to service the whole building. They are generally chosen for complex buildings and or where the cooling or heating load is greater than 100 kW. While packaged plant consists of several packaged plant units that go up to about 100 kW in capacity and integrate fans with cooling and heating equipment.

2.2.3.2.1 Cooling Systems

Cooling systems can be simply divided into three main types as follows: fans, evaporative coolers, and refrigerative air conditioners (Energy Information Centre 1997d, Energy Victoria 1997f). The systems have different running costs and are suitable to different types of climate.

- ***Fans*** produce a cooling effect by moving air but do not reduce temperature. They have the lowest running costs. They are a good option in a warm climate.

- ***Evaporative coolers*** draw outside air through a moistened filter pad, cooling it by approximately 8 to 12°C. The air is then blown through the building at a high air flow rate and expelled to the outside air. They have less than half the running cost of refrigerative air conditioners and are a good option in a hot dry climate. Most commercial installation use ducted systems.

- ***Refrigerative air conditioners*** remove heat to achieve a set temperature, remove humidity, and filter and circulate air from the building. They have the highest running cost. They are available as window/wall split system and ducted models. Reverse cycle models also provide heating. They are a very good option in hot and humid climate.

2.2.3.2.2 Heating Systems

While most cooling systems use electricity, heating systems, on the other hand, can be run on a range of energy sources, usually electricity, natural gas and LPG. The best option for in an aged care building will depend on the energy source available, energy tariffs, and the type of area being heated. The cost of space heating depends on the cost of the fuel used, the efficiency of conversion of fuel to heat, and the extent of the distribution losses in supplying the heat when and where it is needed (DOE 1997c: 8).

Table 2.7 shows comparative running cost for different types of heaters with different types of fuels used in Tasmania (Todd 1997). The costs are based on March 1997 Hobart fuel costs. Electricity is a relatively expensive energy source for heating the whole building, except where special tariffs are available from the local supply authority. However, its special advantage are that it is one hundred percent efficient, storage is not normally required, nor flame or ignition is needed to set it into operation. While gas heaters using natural gas or LPG are less efficient than electric heaters, since there are energy losses associated with flue gas losses and the pilot flame (Todd 1997, ANZEC 1991: 5). In Tasmania, running costs of gas heaters are higher than electricity because LPG must be used (Table 2.7).

Heater Type	Fuel Cost	Fuel Energy Content	Efficiency of Use	Cost of heating
1) LP Gas Heater	128.9 c/kg	50 MJ/kg	75%	3.44 c/MJ
2) Electricity Heater				
2.1 Household tariff				
Heater	7.39 c/kWh	3.6 MJ/kWh	100%	2.05 c/MJ
Heat Pump	7.39 c/kWh	3.6 MJ/kWh	250%	0.82 c/MJ
2.2 Hydro-heat tariff				
Heater	6.064 c/kWh	3.6 MJ/kWh	100%	1.68 c/MJ
Heat Pump	6.064 c/kWh	3.6 MJ/kWh	250%	0.67 c/MJ
2.3 Offpeak tafiff				
Heater	5.77 c/kWh	3.6 MJ/kWh	90%	1.78 c/MJ

TABLE 2.7
Tasmanian Home Heating Costs 1997 (Todd 1997)

The cost of LPG increased in 1997, with a 71% increase from around 21 cents per litre to 36 cent per litre (DPIE 1997: 17). The price is subject to seasonal demand in Australia but also from demand during northern winter.

There are two main types of heat emitted from the heaters which are convection heating and radiant heating (Energy Information Centre 1997d).

Radiant heat is emitted from hot surfaces such as the surface of a heated concrete slab, a bar radiator, or the glowing panel of a gas heater. Radiant heat heats objects within the room directly, but does not directly warm the room air. Radiant heaters use infra-red radiation to create a beam of comfort in front of the heater. Hence, people within the beam can feel comfortable even if the air is cold. They are most appropriate to use in large open spaces or high ceilings or are particularly draughty areas such as a bathroom.

Convective heat is heat which is transferred from one object to another, using moving air. Convection heaters directly heat the air. They are most appropriate to use in well insulated rooms, open plans areas which are not draughty, and have average ceiling height.

Heating systems can be simply divided into two main types which are 1) central heating systems and 2) space heaters (Energy Victoria 1997g). Central heating systems are large heaters capable of heating most of a building at one time such as ducted air heaters, hydronic heating, in-slab heating, and electric thin-film heaters. Space heaters are designed to heat a zone, rather than the whole building such as, gas space heaters, off-peak electric storage heaters, heat pumps, and electric space heaters. Different systems have different running costs.

- Ducted Air Heaters

Ducted air heaters are convection heaters which circulate warm air around the building through insulated ducts which enter rooms through the floor or ceiling. They are typically run on gas, but electric heat pumps are also available.

- Hydronic Heating

With this type of heating system, water is heated in a boiler and then circulated around the building to radiator panels, skirting board convectors or fan coil convectors that heat the room by convection and radiation. They are typically fuelled by natural gas, LPG, or off-peak electricity.

- In-slab Heating

With this type of heating system, a concrete slab is heated by internal electric cables or hot water pipes. They give off radiant heat which is suitable for rooms with high ceilings. They are typically fuelled by off-peak electricity (for cable) and natural gas or LPG (for hot water pipes). Solar systems are also available. This heating system has a slow response time (6-8 hours) to changes in thermostat setting which means system should be set and left for 24 hour heating.

- Electric Thin-film Heaters

These types of heaters have thin films installed in the ceiling, in wall panels or under floor coverings to give radiant heat. They operate on "day rate" electricity.

- Gas Space Heaters

Gas space heaters produce convective heat, radiant heat, or a combination of the two. They run on natural gas or LPG. The units are available to heat from areas of 30 m^2 up to 100 m^2.

- Off-peak Electric Storage Heaters

Off-peak electric storage heaters are radiant or convection heaters which store off-peak electricity as heat in storage bricks. Storage radiators deliver 24 hour background heat for areas up to 30 m^2.

- Electric Space Heaters (Fixed and Portable)

Electric space heaters are convection or radiant heaters which use "day-rate" electricity. These include electric radiators, electric fan heaters, electric convection heaters, and oil filled heaters. They may be very expensive to run. However, this depends on the electricity tariff and the cost of alternatives. For instance, in Tasmania they can be cheaper to run than LPG heaters (Table2.7).

2.2.3.3 Lighting

Lighting has been a prime target of energy conservation programs and policies all over the world for many reasons (Vorsaltz 1996: 3). First, there are few other energy end-uses with as short a lifetime as lighting, especially incandescent lighting. Second, the lighting equipment has a low first cost, thus its retrofit does not require the investment of large amounts of capital. Third, there are few other end-uses where the efficient alternative can demonstrate 60%-75% energy savings while maintaining the level of energy service. Fourth, lighting accounts for a significant portion, about 40%, of commercial electricity use and represents an important share of energy bills of every business (Sezgen *et al.* 1994: 1).

In Australia, the potential for low-cost savings also makes lighting very attractive for energy conservation program planners. A study by Harris *et al.* (1996: 2) states that the largest number of Australian energy audit recommendations are in the lighting sector.

In the health care sector, including old people's homes, the buildings have higher annual lighting hours and lighting levels than other types of commercial buildings such as offices, restaurants, retail outlets, schools, and warehouses (Sezgen *et al.* 1994: 8). A study by Vorsatz (1996: 116) shows that health care facilities use almost twice as many Watts to illuminate a unit area and also have twice as long lighting hours as most commercial buildings. This is due to 24 hour operation in many areas as well as the need for well lit areas to meet the requirements of elderly people with failing eyesight and visual medical tasks in special purpose areas.

The selection of an appropriate source for interior lighting in an aged care organisation must be a balance of efficiency, reliability, and cost (both initially and throughout the lighting system's life).

It is important in aged care buildings that elderly residents are able to see clearly and to identify objects, services, signs, clocks, and changes of level for security reasons. Hence, lighting has become an even more important task, compared to other types of commercial buildings. However, it is not only a matter of intensity of light provided, but rather its ability to emphasise contrast. A combination of general and localised task lighting allows this and so should be clearly defined by energy auditors (Valins and Scott 1996: 70).

Two main types of interior lighting used in aged care facilities are: (1) incandescent lamps and (2) fluorescent lamps.

The most cost effective lighting retrofits are offered in buildings where incandescent lighting represents a high portion of the lighting energy use (Vorsatz 1996: 217). Replacing incandescent lamps with more efficient fluorescent fittings such as compact fluorescent lamps or fluorescent tubes can save up to 75-80% of lighting costs and more with labour cost savings (Energy Victoria 1994: 27, CAE 1996: 279).

Currently, in US health care buildings, fluorescent lamps provide the majority of delivered lumens by lamp type for interior lighting, about 96.7 %, while only 2.1% is provided by incandescent lamps, and 1.2% by high intensity discharge (Vorsatz *et al.* 1997: 31). This study shows that the incandescent percentage number in the US health care sector is much lower than in other sectors such as public assembly, lodging, restaurant, and small office; but it is still slightly higher than in large office buildings.

However, disposal of compact fluorescent lamps is an environmental issue because of the mercury contained in each lamp. Mercury, which is a toxic heavy metal is used to excite the phosphors in the lamp and is gradually deposited onto the glass, filaments, and phosphors (Koomey *et al.* 1994: 25).

All fluorescent lamps require ballasts that absorb energy in different amounts depending on their quality, to limit current flow through the lamps (Vorsatz 1996: 81). For example a 30 Watt fluorescent lamp ballast can have losses as high as 13 Watts (Northern Territory Government Energy Management Program [NTGEMP] 1998: 29). However, electronic ballasts typically have ballast losses of only 3 Watts with a payback period typically around two years depending on operating hours and electricity price (Koomey *et al.* 1994: 12).

Three main categories of outdoor lighting which are used in aged care facilities are: (1) incandescent lamps; (2) fluorescent lamps; and (3) high intensity discharge (HID) lamps.

HID lamps are much more expensive and more specialised in their application than incandescent and fluorescent lamps (DPIE 1986: 6). The three main types of HID lamps in general use are: metal halide, mercury vapour and high pressure sodium.

External lighting is required for security purposes and to enable staff, visitors and residents to move outside safely. Hence, external lights are usually operated all night, 365 days a year. Installation of higher efficiency lamps, such as compact fluorescent lamps, instead of incandescent lamps can lead to substantial cost savings (Table 2.8).

Bulb	Capital lamp cost	Electricity cost	Total cost
60 Watt incandescent	$10 ($1 x 10 lamps)	$32.81	$42.81
15 Watt compact fluorescent	$23 ($23 x 1 lamp)	$8.20	$31.20

TABLE 2.8

Cost comparisons over two years between using 60 Watt incandescent lamps and a 15 Watt compact fluorescent lamp. Calculation assumes an average 10 hours per day for exterior lighting (3,650 hours of use per year), a cost of $0.07492 per kWh of electricity (current Tasmanian prices), and lives of 750 hours for each incandescent lamp and 7,500 hours for each compact fluorescent lamp.

This occurs despite higher initial capital costs because the incandescent globes consume more electricity per light output and need to be replaced much more often than more energy efficiency lamps (Table 2.9). Reduced labour cost associated with lamp replacements is another benefit of using energy efficiency lamps.

	Standard Incandescent lamp	Fluorescent Tube	Compact Fluorescent	Mercury Vapour Pressure	Metal Halide Pressure	High Pressure Sodium
Efficacy (lm/W)	8 - 17	60 - 100	40 - 65	15 - 70	60 - 100	60 - 120
Average life (hr)	700-1,000	7,000-9,000	7,000-9,000	8,000-24,000	8,000-10,000	14,000-24,000

TABLE 2.9
Lamp efficacy and life (Energy Information Centre 1997c)

Correct control of the lighting system will ensure that energy is not wasted and standards are maintained. Thus, to achieve lower operating cost it is important to provide a means of flexible lighting control, for instance manual switching, occupancy sensor (motion detectors), time switching, photoelectric switches, and dimming control to suit building occupancy patterns (NTGEMP 1998: 29). However, the type of control device should be decided before the installation is commenced, as the cost of installing a more suitable device at a later stage may well exceed any financial saving made through lower energy usage (DPIE 1986: 15).

2.2.3.4 Building fabric

Opportunities for energy conservation exist in all aspects of aged care building design, construction and operation from initial site selection and landscaping to building fabrication selection. This section provides guidelines for building envelope construction in the interest of energy conservation.

Decisions taken during the design and construction of an aged care organisation will greatly influence the building's lifetime running costs. Many energy efficiency features can be specified at the design stage. Although some of these can be incorporated after the building is completed, they will hardly ever be as cost effective as when specified from the beginning.

New aged care buildings, benefiting from past experience and rapidly developing technology, should be well insulated and airtight, and lighting should become even more efficient. Some aged care building designs combine 'passive solar energy', with glazing to encourage natural daylight and contribute to heating needs (Valins and

Salter 1996: 155-156). A study of low energy housing for the elderly in New Zealand (http://194.17286/register/data-ee/cce00636.htm: 16/01/2000) was considered solar design as an ideal alternative to provides lower energy and maintenance costs, as well as better comfort conditions. The investigation found that the passive solar design resulted in lower internal temperatures (cooler) in summer and higher (warmer) in winter. Energy cost savings were shown by thermal modelling and measurement.

The most common building features found in many aged care constructions that require improvement are: inadequate insulation in ceilings, floors, and walls; many areas of roof glazing or skylights including vented skylight; large areas of wall glazing; and draughts.

Inadequate insulation in ceilings, floors and walls are commonly found in many old people's homes and are major causes of energy waste in most homes. The use of building fabric with better insulation is probably the most obvious and cost-effective form of energy conservation (Johnson and Wilkes 1993: 69). Insulation performs two important functions: it reduces the rate of heat loss through the building envelope; and it increases the temperatures of the inner surfaces of the building (Todd 1994a).

Standards Association of Australia [SAA] (1983) recommends insulation levels for various locations in Australia, based on climatic differences as well as energy and insulation cost. Even though these are just recommendations rather than regulations, it is important, particularly in old buildings, that the buildings meet these standards.

Many State government building regulations have included minimum requirements for building insulation. However, this is not always the case. For instance, in Victoria specified minimum levels of insulation in external walls, ceilings, and floors are required for all new homes and extensions (Energy Victoria 1995: 14), while in Tasmania, there are no such regulations.

Energy Victoria (1997c) recommends insulation is installed in: ceilings, saving 20% to 30% on heating and cooling energy required; external walls, saving an additional 10% to 20%; and floors, saving another 5% to 10% on energy costs.

Nevertheless, a study in New Zealand by Bannister *et al.* (1995: 358) suggests that insulation is viable for roofs and exposed floors throughout New Zealand but in some areas, the wall insulation is not viable as an addition to roof insulation. The study (Bannister *et al.* 1995: 358) shows that in Auckland [similar climate to Adelaide (Isaacs *et al.* 1996: 97)], insulation causes a significant decrease in heating energy, but the cooling energy increases at the same time. In particular, wall insulation achieves a further small reduction in heating energy which is largely counteracted by the associated increase in cooling energy. However, in colder areas like Christchurch [similar climate to Canberra and Hobart (Isaacs *et al.* 1996: 97)], the reduction in heating energy is far more significant for both roof and wall insulation and the associated increase in cooling energy is much smaller.

Daylighting refers to the admittance of natural light to a building (Energy Victoria 1994: 21) and is an important in the design of an aged care building. As elderly residents may become less able over time to leave the facility, many home designs therefore, need to introduce daylight to emphasise the sense of time as well as place to the elderly residents (Valins and Scott 1996: 70).

Skylight is an option to introduce natural light to an aged care building. Skylights and vented skylights are very popular and have been used in many areas of old people's homes (DOE 1997b: 10). Skylights are horizontal openings in the ceiling surface, which bring in a great deal of light with a minimum amount of glazing area (International Energy Agency (IEA) 1994: 187).

Unfortunately, this option of increasing natural light often results in undesirable heat gain or loss to the building. Their horizontal aspect permits substantial entry of direct sunlight during summer, when sun angles are high, increasing heat load on the building at a time when energy is being used for its cooling. However, during winter when sun angles are lower, they facilitate little entry of direct sunlight when it is needed to reduce energy use for warming the building. Moreover, greater heat transfer through skylights than ceiling and roof materials allows heat to escape from the building (Energy Victoria 1994: 22). They can also cause uncomfortable draughts if not properly protected.

To solve the problems, Energy Victoria (1997b) suggests using an integrated skylight such as one with angled louvres integrated into the diffuser or the double glazing unit; or an unvented diffuser fitted at ceiling level to reduce down-draughts from a skylight. Because it prevents warm air rising then cooling when in contact with the cold surface of the skylight and falling back into the room (see Figure 2.4).

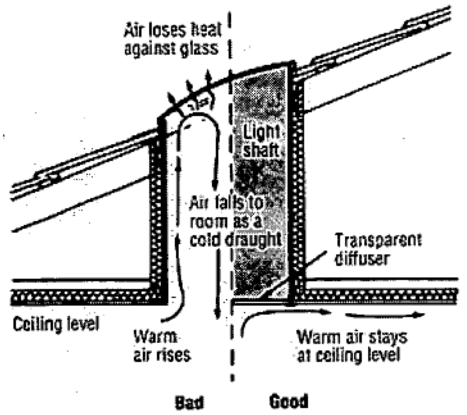


FIGURE 2.4

Sealing a skylight with a diffuser at ceiling level will reduce down-draughts from the skylight (Energy Victoria 1997b)

However, almost all roof constructions are less expensive and better insulators than even the best skylights, also the integration of skylights which avoid all leakage can be very expensive (IEA 1994: 187). Thus it seems advisable to avoid skylights in heated areas and limit them to unheated bathroom, toilets, laundries and hallways (Energy Victoria 1995: 13).

Another option of increasing natural light is north facing windows. Day rooms with large areas of wall glazing faced north are present in many aged care buildings (DOE 1997b: 10) for elderly residents to delight in natural light as well as outdoor scenery and heat. The north facing windows receive winter sun allowing light and warmth into the room. They are better than the skylights because they can be easily shaded in summer to help keep the home cool (Energy Victoria 1995: 10).

However, window glass influences occupant comfort by heat gain or heat loss through the glass, which either raises or lowers the room air temperature. In winter, unprotected, single panes of glass lose 10 times more heat than the same area of insulated wall (Energy Victoria 1995: 13, 1997b). Hence if north facing windows are too large, high heat losses at night and during cold cloudy days can increase heating requirements.

Moreover, the internal glass surface temperature also influences occupant's thermal comfort by long wave radiation exchange between the occupant and the window

(Button *et al.* 1993: 121). In winter, the glass surface can be much colder than other room surfaces, producing a loss of heat from the occupant's body surface by long wave radiation to the colder glass surface and contributing to a sensation of cold discomfort.

As the day rooms in old people's homes are usually constantly occupied and heated, it is worth considering increasing the thermal resistance of the windows. This may be achieved by installing a higher standard of glazing, such as double glazing. Additional gains can be achieved by installing long curtains with close fitted pelmets to create a still air space between the glass and curtain. The layer of air space provides extra thermal resistance by virtue of the low thermal conductivity of air, compared with glass (Button *et al.* 1993: 121). However, long curtains with close fitted pelmets are of limited value since rooms in an aged care building are normally heated and occupied during the daytime and elderly residents usually open the curtains to enjoy outdoor scenery. Even if closed, the thermal resistance of long curtains with close fitted pelmets (0.2 m^2K/W) is still less than that of double glazing (0.32 m^2K/W) (Todd 1994c). However, installation costs are much higher for double glazing (Todd 29/11/99, *pers. comm.*).

Draughts or infiltration of cold air in winter can result in considerable discomfort to elderly residents hence a large additional energy consumption is needed if they try to combat the problem with heating. Energy Victoria (1995: 9) notes that draughts and unwanted air leakage can increase heating costs by more than 20%. Draughts are the results of cracks, opening around windows and doors, and access openings.

Preventative measures, for instance draught proofing doors and windows using draught excluders or weatherstrips, sealing gaps and cracks with caulking compound, and sealing permanently vented skylights in heated areas, are recommended (Energy Victoria 1997e). Vertical shafts such as stairwells also have to be isolated by putting in a new wall and door to isolate the staircase (Thumann 1998: 135-147).

2.2.3.5 Kitchen

The energy in a kitchen is used for cooking, food preparation, serving and storing, sanitation, dish washing, general use of hot water, ventilation and lighting. Up to one-fifth of the energy in an old people home is used in kitchen, for instance cooking 7.8% and refrigeration 1% (DOE 1996a: 4).

Running costs of refrigerators and freezers vary according to: the size and efficiency of the unit; the effectiveness of the insulation; and the outside temperature for instance, in hot weather, heat will leak into the cabinet more quickly, requiring more energy to maintain low temperature (Sustainable Energy Development Authority [SEDA] 1998).

The Energy Information Centre (1997b) suggests that refrigerators and freezers should be installed in a well ventilated location and away from direct sunlight or other source of heat. The condenser coils at the back should be cleaned to allows heat to be carried away more effectively. Recommended temperature settings for refrigerators are 3-4°C, and minus 20°C for freezers as every degree lower than this increases running cost by 2-3% (Energy Victoria 1996: 16).

The majority of energy used by a dishwasher is for water heating. A study by Horwood (1993: 64) reported that commercial dish washing machines heat the washing water to around 80°C. It is desirable, therefore, to supply hot water to dishwashers from an external hot water supply to reduce the cost of dishwasher hot water (if a lower cost source of energy such as natural gas are available). However, a study by Sustainable Energy Development Authority (1998) advises that a dishwasher should not be connected to an external hot water supply but connected to a cold water supply instead because this allows: the heating of water only to the temperature necessary (around 50-55°C), rather than using water from the hot water service (which may be 60-70°C); full use of programs with various temperature setting; and the machine to heat water only when required, i.e. for two of the five wash cycles (the main wash and the final rinse). The advice applies unless the external hot water supply is a sufficiently large off-peak electric or high efficiency gas hot water system.

However, it should be noted that some state regulations might have hot water temperature requirements for dish washing machines for public health reasons. For instance, the WA Consolidated Regulations 1993 set the minimum requirement of hot water temperature for dish washing machines at 75°C for fresh hot water or 50°C with a chemical sanitizer (State of Western Australia 1998a); while the Northern Territory Government Consolidated Regulations set at 165°F or 73.9°C (Northern Territory Government 1997).

In Victoria, as using natural gas can reduce cooking energy costs by up to two thirds (Energy Victoria 1996: 17), it is preferable to use gas energy for cooking or keeping food hot. Moreover, gas cookers also use less energy than electric cookers (DOE 1996c: 4).

2.2.3.6 Laundry

The laundry typically represents about 10% of the energy costs in an old people's home (DOE 1997a: 3). The energy in a laundry is primarily used for clothes washing and drying, other use of hot water, ironing, ventilating, and lighting.

Washing machines and tumble driers in both commercial size and household size are generally used to serve the demands of a number of residents in the homes. When this equipment is being purchased or replaced it is usually possible to choose an energy efficient model. For instance, choosing tumble drier and clothes washer models which have heat recovery system may be expensive, but around 40 percent of energy can be saved and typically achieve payback periods of approximately two to three years (Hunt 1983: 129).

Tumble driers, in particular, consume a large amount of energy due to creating hot air for drying clothes inside them. In Victoria, where natural gas energy is much cheaper than electricity (Energy Victoria 1996: 17), laundry costs are reduced by using gas-fired rather than electric tumble driers. Similarly in the UK, manufacturer's data show that the annual running cost of a gas-fired tumble drier with an 8 kg capacity drying five loads per day would be about one-fifth of that using an equivalent all-electric model (DOE 1997a: 3).

Hot water needs vary from laundry to laundry depending on washer equipment, type and concentration of detergent. The Energy Efficiency Best Practice program by Department of Environment (DOE 1996c: 3) suggests some practical ways to save energy in a laundry by using hot water from the hot water system rather than electric heater in the machine, and, where possible, choosing a low temperature detergent and setting wash temperature as low as possible. However, it should be noted that some state regulations might have hot water temperature requirements for clothes washing machines for public health reasons. For instance, the WA Consolidated Regulations 1993 set the minimum requirement of hot water temperature at 75°C for each washing machine provided with the communal facilities (State of Western Australia 1998b).

2.3 CONCLUSION

This chapter has presented a brief overview of background information on energy management and processes of building energy auditing. The information on the use of energy efficiency technologies for aged care organisations was also reviewed in the areas of hot water, heating, ventilation and air conditioning, lighting, building fabric, kitchen, and laundry. The potential energy saving in an aged care organisation can be investigated by comparing the energy performance indices of the organisation with energy targets.

CHAPTER 3

OVERSEAS BEST PRACTICE ENERGY STANDARDS

This chapter examines overseas best practice energy standards for aged care buildings. Information in this chapter is divided into four sections. The first section provides an introduction; the second identifies what is 'best practice energy standards' for aged care buildings; the third examines which countries have 'best practice' in energy standards for the aged care sector; and the last section is conclusion.

3.1 INTRODUCTION

The United Nations defined the term 'best practice' as that which makes outstanding contributions to improving the living environment (http://dubai-award.dm.gov.ae/ awards1.html: 14/01/2000). However, the term 'best practice' has been used in various fields in relation to environmental harm, which has resulted in many different definitions, such as:

- best practice environmental management = a management of the activity to achieve an ongoing minimization of the activity's environmental harm through cost-effective measures assessed against the current international and national standards applicable to the activity (Environmental Management and Pollution Control Act [EMPCA] 1994);

- best practicable environmental option = a concept used in cost-benefit-risk analysis, especially in UK, to set regulatory limits on activities, e.g. emission of pollutants (Lawrence *et al.* 1998, Porteous 1992);

- best management practices = a required program minimise risk, e.g. through the control potential spill or release of harmful material to surface waters, such as dikes to contain tank overflows or heavy rainfall runoff (Stevenson and Wyman 1991); and

- best practice means = an approach to air pollution control under the Alkali and Clean Air Inspectorate in Britain, which takes into account the economic and technological realities of the operation of specific industrial plants (Kemp 1998).

The term 'best practice' has also been used in the field of building energy conservation. However, from the reviews, it is apparent that 'energy best practice' in building energy conservation has not yet been defined (http://www.dpie.gov.au/netenergy/best/overview.html: 14/01/2000, http://www.etsu.co.uk/html/body_hosted.html#eebpp: 14/01/2000).

According to the Department of Industry, Science & Resources in Australia (http://www.dpie.gov.au/netenergy/best/overview.html: 14/01/2000), the Energy Efficiency Best Practice (EEBP) Program aims to stimulate energy efficient best practice in Australian business. The Commonwealth government has allocated $10.3 million over a five-year period from mid-1998 to support the EEBP program. This program will identify the energy characteristics of a range of industry sectors and the performance of individual entities within those sectors to establish a profile of energy performance and thereby obtain benchmarks for best practice.

The Energy Efficiency Best Practice Programme (EEBPP) in the United Kingdom is a key part of the UK Government's commitment to improving energy efficiency. The UK EEBPP aims to stimulate the incorporation of energy efficient good practice throughout the industrial, commercial, public, and domestic sectors (http://www.etsu.co.uk/html/body_hosted.html#eebpp: 14/01/2000). Considerable effort has been made by the UK government, in the form of publications, seminars, courses, competitions and advertising, to encourage energy efficiency. For example the *Energy Audit Series*, published by the UK Department of Energy, seeks to promote 'best practice' in energy terms in several sectors (Smith and Collett 1988: 150-152).

Definitions of best practice energy standards, once defined, will differ between existing buildings and proposed buildings. For example, energy efficiency in new buildings can be enhanced through architectural planning by incorporating passive solar designs and the use of materials with good insulative properties. This option is clearly not available to existing buildings, where improvements can only be achieved through minor alterations. As this study involves conducting energy audits on existing buildings, it is these minor alterations which are to be considered here.

3.2 Definition of "Best Practice Energy Standards" for Aged Care Buildings

The usual starting point in defining best practice for energy management is to set a benchmark at the standard achieved by the most energy efficient organisations or countries. By comparing the standard of the organisation or country being assessed against this benchmark it is possible to reveal the potential for improvement (Construction Industry Development Agency 1994: 23).

Best practice energy standards for aged care buildings can be derived from three approaches.

Energy Consumption (lowest)

Energy Technology (highest)

Energy Legislation (most stringent)

3.2.1 Energy Consumption

Energy consumption indices give a measure of the energy use of a building which can be compared with the accepted standard performance indices or yardsticks (DOE 1997c: 14). They can indicate the potential for improvements and allow comparisons to be made between buildings. Energy consumption indices are obtained by dividing the annual building energy consumption by either the number of residents, the floor area, or the volume of the building.

The use of energy consumption as a benchmark for best practice is the most favoured approach because the ultimate goal of energy audits is a reduction in energy use by identifying energy conservation opportunities. Nevertheless, the effectiveness of this approach may be limited by a lack of data available from particular organisations or countries. Another problem associated with this approach is the varying energy demands for temperature regulation in different climates (DOE 1996c). Energy use is typically greater in extreme climates than milder ones. However, it is possible to correct comparing energy consumption data for cold or hot weather using 'degree day' data (DOE 1996b). Examples of calculations using weather correction factors to adjust cooling or heating energy consumption are shown in Section 3.3 Overseas Best Practice Energy Standards.

In the United Kingdom, energy surveys were conducted in many aged care organisations by the UK Department of Environment to establish Energy Performance Yardsticks for aged care buildings (Tables 3.1, 3.2 and 3.3). Each building is placed in one of three bands according to the total amount of energy used: per resident; per unit of floor area; and per unit of building volume. The categories used are good, fair and poor, and have been set using the data collected during the energy surveys. The 25% of buildings with the lowest energy consumption are used to classify the good category, the 25% with the highest energy consumption to classify the poor, and the remaining 50% make up the fair category. Electricity and fossil fuels (gas and oil) are shown separately.

Performance Classification	Fossil fuels (kWh/bed)	Electricity (kWh/bed)
Good	< 9633	< 1704
Fair	9633 – 16263	1704 - 3173
Poor	> 16263	> 3173

TABLE 3.1
Energy performance yardsticks for United Kingdom aged care buildings per resident (DOE 1996a: 3)

Performance Classification	Fossil fuels (kWh/m^2)	Electricity (kWh/m^2)
Good	< 247	< 44
Fair	247 - 417	44 – 79
Poor	> 417	> 79

TABLE 3.2
Energy performance yardsticks for United Kingdom aged care buildings per floor area (DOE 1996a: 3)

Performance Classification	Fossil fuels (GJ/100m^3)	Electricity (GJ/100m^3)
Good	< 54	< 6.0
Fair	54 – 68	6.0 - 7.5
Poor	> 68	> 7.5

TABLE 3.3
Energy performance yardsticks for United Kingdom aged care buildings per building volume (DOE 1997c: 15)

However, in this study, the weather correction factor used (2462 annual heating degree days, based on an assumed indoor temperature of 15.5°C (DOE 1997c: 26)) does not take into account climatic variations between different regions of the UK, or annual climatic variations within any particular region. Weather differences between regions of the UK are typically sufficient to cause variations in heating or cooling energy use of ±10% from average values and up to ±20% in more extreme areas (DOE 1997c: 24). Typical weather changes from year to year in any given region cause variations in heating or cooling energy use of ±5% from the average values or ±10% in more extreme years (DOE 1997c: 24).

In the United States, the Department of Energy's Energy Information Administration has conducted energy surveys in various US commercial buildings (EIA 1992, 1994, 1998). Buildings were grouped into different categories by their activities or functions which occupied the most floorspace of the buildings (EIA 1994: 128). In this classification, the Health Care category was only applied to buildings used as diagnostic and treatment facilities for both inpatient and outpatient care. This category included: medical care hospitals; dental, medical and mental health clinics; and mental, rehabilitation and veterinary facilities (EIA 1998: 366). Buildings used to offer multiple accommodation for short-term or long-term residents such as those providing 24-hour nursing or medical care, including skilled nursing or other residential care, were placed along with hotels, motels, and dormitories in the Lodging category (EIA 1998: 366).

Average energy consumption for buildings in the Lodging category was around 386 kWh/m^2 in 1989 (EIA 1994), and increased to 402 kWh/m^2 in 1995 (EIA 1998). However, this small increase was not uniform across all energy consuming sections (Table 3.4). Energy consumption increased dramatically in the cooling, lighting, water heating and office equipment sections. Introduction of more air conditioning and the presence of extra computers and office equipment are some of the main reasons for the trend. In contrast however, the consumption decreased substantially in the space heating, ventilation, cooking and refrigeration sections partly by the use of modern, well controlled boiler plant and heating system (Table 3.4).

Energy consuming sections	Average annual end use intensity (kWh/m^2) 1989	1995
Space Heating	123.98	71.61
Cooling	15.46	25.55
Ventilation	18.30	5.36
Water Heating	113.26	162.16
Lighting	42.59	73.19
Cooking	29.02	20.82
Refrigeration	14.20	7.26
Office Equipment	1.26	12.00
Other	27.76	23.66
TOTAL	385.83	401.61

TABLE 3.4

Average annual end-use intensity for US buildings in the Lodging category in 1989 and 1995 (adapted from EIA 1994, 1998)

In Denmark, a report by ØSTKRAFT Department of Energy Efficiency (1995) showed that the national average consumption for aged care organisations or other similar institutions, such as those providing residential care for people with disabilities, was 71 kWh/m^2 for electricity and 239 kWh/m^2 for fossil fuels. The average for the 25% of institutions with the lowest energy consumption was 54 kWh/m^2 for electricity and 150 kWh/m^2 for fossil fuels. Annual heating degree days for an average year in Denmark is 2731 degree days (based on an assumed indoor temperature of 15.5°C).

3.2.2 Energy Technologies

The use of energy efficiency technologies as a benchmark for best practice is problematic. Technologies in term of lighting are probably suitable for defining benchmarks. However, technologies associated with temperature control cannot be compared across different climates because the technologies which are adequate in mild climates may be unsatisfactory where extremely high or low temperatures occur. For instance, roof and wall insulation thicknesses recommended by the European Insulation Manufacturers' Association (Eurima) differ greatly between European countries (Figure 3.1). This approach is also more difficult to adjust to take into account differences in climates between areas than is the energy consumption approach.

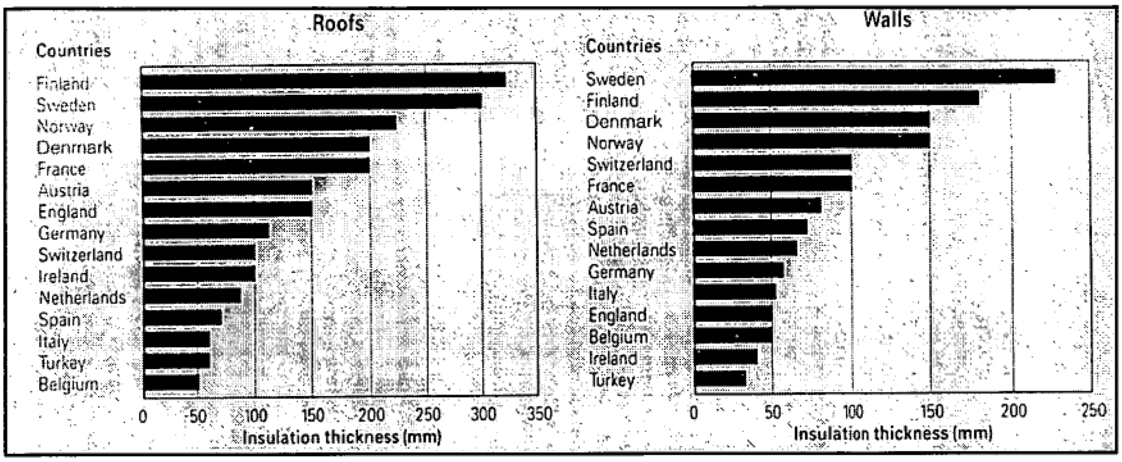


FIGURE 3.1

Recommended insulation thickness in European countries (Housing in Europe, Eurima, April 1991 in Johnson and Wilkes 1993: 71)

However, upgrading of technology can lead to substantial reductions in energy demands. For example, the Batley Hall nursing and residential home in the United Kingdom has successfully incorporated energy efficiency measures into refurbishment projects (DOE 1996d: 2). In 1992, all three gas-fired boilers (each is serving a separate radiator system and hot water cylinder) were fitted with their own programmable controller. Thermostatic radiator valves were also installed to allow for adjustment in individual rooms. After installation of new boiler controls, gas consumption was cut in half and remained at that level, reducing the total fuel bill by nearly 30%. Other energy saving refurbishments included installing 200mm of mineral fibre insulation in a previously uninsulated roof. In addition, compact fluorescent light bulbs replaced many conventional lamps, both indoors and outdoors, in 1995. Timed and photocell controls were installed with the outside lights, so that they only operate when required.

Similarly, the McCone County Nursing Home in Montana, USA, implemented energy saving building retrofits in 1984 (http://194.178.172.86/register/data-ee/cce01313.htm: 14/11/1999). The building used electric resistance baseboard heaters, 100% outside air multi-zone units for ventilation and cooling, and electric domestic hot water heaters. The existing hot water heaters were replaced with a water to water heat pump. Existing single speed motors on the HVAC unit and exhaust fan were replaced with two speed motors to allow a reduction in operation volume at certain times. An energy management system was installed to duty-cycle the HVAC units and exhaust fans and to shed electrical load in a pre-assigned sequence. After the retrofittings, it was found that electrical consumption decreased by 97 kWh/m^2, or 15% of pre-retrofit usage. The total cost of the retrofit measures was $US 49820, and the payback period was around 3.9 years.

Gorlev old people's home in Denmark upgraded their hot water system in 1991 (http://194.178.172.86/register/data-re/ccr01904.htm: 14/11/1999). The new system is a combination of natural gas and solar heating. The existing boilers were replaced by wall-mounted, condensing gas boilers. Solar collectors with an area of 77 m^2 were installed and a new 2000 litre solar heated hot water storage tank was combined with the existing water storage tank. Five natural gas boilers provide the heat when the solar collectors do not provide enough hot water. Commercial operation began in 1991 and performance has been in accordance with expectations. Payback time for the complete system (solar heating and natural gas systems) was less than 5 years.

These examples show that the use of energy efficient technologies can lead to substantial reductions in energy demands. Nevertheless, it is difficult to use as a benchmark for best practice energy standards.

3.2.3 Energy Legislation

Government legislation is probably the least appropriate of the three approaches to defining best practice standards. This is because there is a financial incentive for organisations to save energy to the greatest possible extent. Hence, the energy efficiency of some organisations may exceed that set out in the legislation. For example, the Valley nursing home in the United Kingdom was completed in July 1995 (DOE 1997a: 2). The energy efficiency standards of this aged care building were set to reduce running costs. The standards were significantly higher than the Building Regulations at the time and are also better than the subsequently revised Regulations in many aspects.

In addition, as for the other two approaches, it is difficult to compare legislation between countries. Different climatic conditions are the main reason that countries have having different building codes (Table 3.5). Countries with hot climates, such as Hong Kong, The Philippines and Jamaica, have regulations which concentrate on air conditioning and shading. In contrast, countries in cooler climates, such as Canada and those in Europe, have regulations focusing on heating energy consumption; particularly insulation and heating systems (Table 3.5).

COUNTRY	SPLIT		EXEMPT BUILDINGS	ELEMENTS COVERED
AUSTRALIA	Residential	Commercial	Unknown as yet	Residential: - regional, wall R values Commercial: - under development; probable window size and R values limits; may include simulation program means of compliance;
CANADA	Residential Low Rise: ≤ 3 stories ≤ 600 m^2	All Other Buildings	-farm buildings other than dwellings -seasonal buildings	-building envelope -heating equipment -ventilation equipment -air conditioning equipment -water heating equipment -lighting -electrical power except process loads (trade off against U-values) -ventilation -heating systems -heating control systems
DENMARK	Small buildings, houses -Single -Detached -Semidetached -Terraced -Chain -Cluster	All Other Buildings	-thoroughly ventilated spaces -heated by internal gains (waste heat) -heated only for short periods (All still must be insulated but to level suitable for their use)	- envelope U-Values walls, ceilings, floors, windows - % window area
JAMAICA	Low Rise Residential	All Other Buildings (except low rise residential ≤ 3 storeys above grade)	-manufacturing -commercial processing -industrial processing -buildings with energy ≤ 10.8 W/m^2 -buildings ≤ 93 m^2	Envelope U-Values -window: shade coefficient, external shading, % wall area -lighting -ventilation -air conditioning -service water heating -energy management
GERMANY	ONE CODE Area to Volume ratio used in setting various performance indices for the energy balance calculation. For temperatures >15°C		Small dwellings with up to 2 storeys may use the old average building conductance system of code compliance. ALSO: buildings where: - temperatures <15°C	- Element U-values - solar gain - internal gains - ventilation heat gain/ loss - mechanical/ natural ventilating - heat recovery
NETHERLANDS	Residential -existing -to be built	Non-residential -existing -to be built	Caravans: different regulations, not absence of them. If a process in a building requires cooling, the energy use for this is discounted.	- Element U-values - solar gain - internal gains - ventilation heat gain / loss - mechanical ventilation - air-conditioning - heat recovery
HONG KONG	Hotels	Commercial buildings	- Any space not air-conditioned	ASHRAE OTTV (Overall Thermal Transfer Value: average U value across all building surfaces
PHILIPPINES	ONE CODE: OTTV only where total cooling load > 175 kW;		Residential units; premises with high process heat gain; - peak design energy use -peak design energy used < 10 W/m^2	ASHRAE OTTV; plus specific lighting levels for different building uses.
SWEDEN	ONE CODE dwellings - others (different required U-values)		-Used for short periods -No heating required (greater part of year) -Process heat provides enough heat	-Envelope average U-values -min & max floor temperature -air tightness -ventilation -heat Recovery -window area
USA-ASHRAE	Residential	Non-residential	Depends on implementing authority	
USA – CALIFORNIA	One code (16 climate zones) Different requirements by use type: some common / separate chapters low rise residential – other		-historic buildings -seasonally occupied farm buildings -residential heated by wood fire & non- depletable -hot water -lighting	U-Values of: - walls, floor, ceilings, windows. Window areas & shade coefficients Efficiency of: - space heating and cooling, water heating equipment

TABLE 3.5

Summary of Energy Efficiency in Building Codes from different countries (Isaacs *et al.* 1995:13)

Furthermore, this approach is limited in this study because in Tasmania there is no legislation controlling energy standards for buildings (Todd 20/01/00, *pers. comm.*), and those for Australia are still very limited (Table 3.5). There are, however, recommendations made by the Standards Association of Australia (SAA 1983) which could be compared to legislation in other countries.

3.3 OVERSEAS BEST PRACTICE ENERGY STANDARDS

Because of the limitations of the energy technologies and legislation approaches, the energy consumption approach was chosen as the means by which the benchmark for the best practice energy standards was defined in this study. 'Best Practice Energy Standards for Aged Care Buildings' in this study is, therefore, defined as: *"the energy consumption of the 25% of buildings with the lowest consumption in countries where such data are available".*

From section 3.2.1, available information on national energy consumption standards that related to aged care buildings was from UK, USA, and Denmark. However, as the data for aged care buildings from the USA was not distinct from other buildings in the Lodging category (such as hotels, motels, and dormitories) these could not be compared directly to those in the Tasmanian case studies. Hence, only the data from the United Kingdom and Denmark were chosen because these were specific to aged care organisations, or at least for buildings with very similar characters and operations. As the Danish energy consumption index was only calculated from energy consumption per floor area, the same units from the UK indices were used as benchmarks in this study. Hence the energy consumption indices from the 25% of aged care buildings with the lowest energy consumption levels per m^2, from these two countries, were selected as the benchmarks for best practice energy standards.

The energy consumptions for thermal comfort from UK and Denmark need to be adjusted for their particular weather conditions before being compared to Hobart. This is because energy use for space heating and cooling is significantly influenced by the external weather conditions, including temperature (degree days) and other factors such as wind, sun exposure, and humidity (DOE 1993: 12). However, Thumann (1998: 23) reported that degree days are sufficiently significant to be used as the sole weather correction factor.

The energy requirements for cooling in Hobart, Denmark and UK are negligible compared to those for heating, due to all having high heating degree days but low cooling degree days (Table 3.6). For this reason, together with the absence of air-conditioning in the case studies, only energy consumption for heating will be adjusted to take weather conditions into account.

Location	Annual Degree Days (base 15.5°C) Heating	Cooling
Hobart, Australia[1]	1282	229
Copenhagen, Denmark[2]	3808	68
United Kingdom[3]	2478	213

TABLE 3.6
Comparison of degree day data between Hobart (Tasmania), Copenhagen (Denmark) and the United Kingdom ([1]Bureau of Meteorology [BoM] 2000, [2]Isaacs *et al.* 1995: 27, [3]http://vesma.com/ddd/std-year.htm: 5/02/2000)

As the data from Denmark and UK do not differentiate energy used in heating from that used for other purposes, it is assumed that most of the fossil fuels are used for space heating. In most European countries, space heating results from burning gas or oil (DOE 1997c: 8). Hence, the heating energy for UK and Denmark is adjusted by using their fossil fuels consumption multiplied by their weather correction factors. The weather correction factor for UK or Denmark is simply calculated from Hobart annual heating degree days divided by UK or Denmark annual heating degree days. The annual heating degree days (base 15.5°C) for Hobart (1282) (BoM 2000) and for United Kingdom (2462) and Denmark (2731) from Section 3.2.1, were used in these calculations.

$$\text{Weather correction factor for UK} = \frac{\text{Hobart yearly heating degree day}}{\text{UK yearly heating degree day}}$$

$$= \frac{1282}{2462} = 0.52$$

$$\begin{aligned}\text{Adjusted fossil fuel consumption} &= \text{Fossil fuel consumption} \times \text{correction factor}\\ &= 247\ \text{kWh/m}^2 \times 0.52 = 128\ \text{kWh/m}^2\end{aligned}$$

$$\text{Weather correction factor for Denmark} = \frac{\text{Hobart yearly heating degree day}}{\text{Denmark yearly heating degree day}}$$

$$= \frac{1282}{2731} = 0.47$$

$$\begin{aligned}\text{Adjusted fossil fuel consumption} &= \text{Fossil fuel consumption} \times \text{correction factor} \\ &= 150 \text{ kWh/m}^2 \times 0.47 = 70 \text{ kWh/m}^2\end{aligned}$$

As electricity is the major energy source for all purposes in Tasmanian buildings, the total energy consumption (electricity plus adjusted fossil fuels used) from UK or Denmark is used as a comparison benchmark against that in Tasmania (Table 3.7).

Energy source	UK	Denmark
Electricity	44	54
Adjusted Fossil fuels	128	70
Total Energy	172	124

TABLE 3.7

Energy consumption (kWh/m^2) for buildings in good category for UK and Denmark (adapted from DOE 1996a, ØSTKRAFT Department of energy efficiency 1995). UK values are the highest values for the good category, whereas Danish values are arithmetic means for the good category.

In Australia, research by Brown *et al.* (1986) found that the average annual energy consumption for the 33% lowest energy buildings for hospital wards and theatre blocks in Hobart was 339 kWh/m^2. This annual target figure of 339 kWh/m^2 was the sum of the annual Base Energy Indices for cooling, heating, hot water service, interior lighting, lifts, and mechanical ventilation and pumping in hospital wards and theatre blocks (Table 2.1). The annual Base Energy Index for cooling was adjusted by multiplying the cooling energy index by the cooling factor for Hobart (Table 2.2). In the same way, the annual Base Energy Index for heating was adjusted by multiplying the heating energy index by the heating factor for Hobart (Table 2.2). This Australian target figure is approximately double that of the annual energy consumption of less than 172 kWh/m^2 for United Kingdom and the average annual energy consumption of 124 kWh/m^2 for Denmark. As the European standards are much higher than those in Australia, the best practice energy standards for aged care buildings used as benchmarks in this study were: the annual energy consumption of less than 172

kWh/m^2 for United Kingdom and the average annual energy consumption of 124 kWh/m^2 for Denmark.

3.4 Conclusion

This chapter has presented information on best practice energy standards for aged care organisations. Because of the limitations of the energy technologies and legislation approaches, those two approaches were rejected and the energy consumption approach was chosen. The 25% of aged care buildings with the lowest energy consumption levels from each of Denmark and United Kingdom were chosen to be used as benchmarks of best practice energy standards. They are:

1) The UK total energy consumption of	< 172 kWh/m^2; and
2) The Denmark average total energy consumption of	124 kWh/m^2.

These standards will be used in Chapter 5: Comparisons and Recommendations to assess the Tasmanian energy performance data from Chapter 4.

CHAPTER 4

TASMANIAN CASE STUDIES

This chapter discusses methodology and results of conducting energy audits in four Tasmanian aged care organisations in Hobart. The chapter is presented in two major parts. The first part provides information on Hobart's climate, and describes the four aged care organisations and the methodology used to conduct the audits. The second part presents the results and discussion of the audits and an analysis of the four aged care buildings' energy performances.

4.1 PART 1: SITE DESCRIPTIONS AND METHODOLOGY

4.1.1 The Climate of Hobart, Tasmania

Hobart, the capital of Tasmania, is situated on the Derwent estuary about 30 km north of the open sea, and 7 km east of Mount Wellington [1,270 metres asl]. Temperatures in Hobart are moderated by the nearby ocean and range from -3°C to 41°C (Linacre and Hobbs 1977: 183). The average monthly air temperatures for Hobart are shown in Figure 4.1.

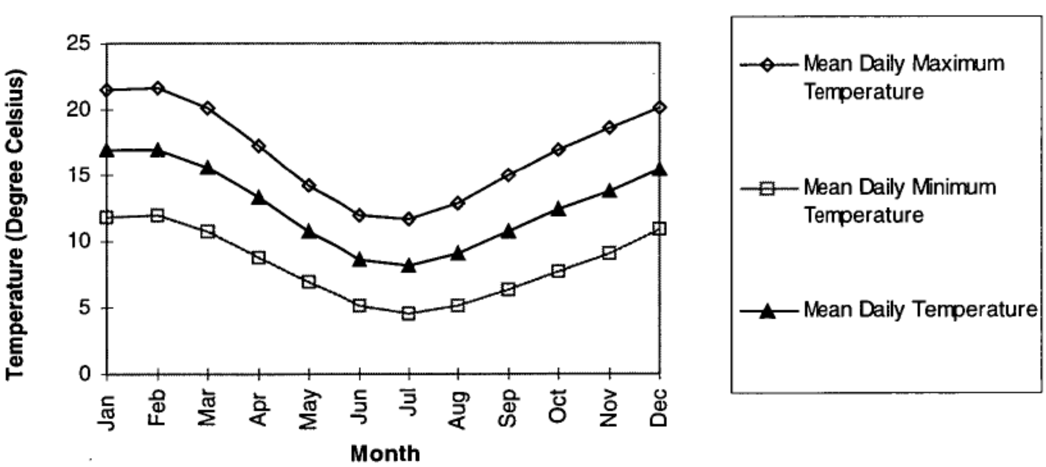


FIGURE 4.1
Mean daily, maximum, and minimum air temperatures in each month (1881-1998) for Hobart (BoM 1999)

The mean daily temperature in each month in Hobart is below 18°C all year round (Figure 4.1). Moreover, daily maximum temperatures above 30°C occur on an average of only six days a year (BoM 1997). Hence, little energy is required for reducing ambient temperatures within buildings to the desired standard of 18-24°C (McGregor 1994). In winter, mean maximum temperatures are substantially lower than this desired standard and mean minima are much lower than this (Figure 4.1). Even in summer, the mean daily minimum temperature is less than 12°C (Figure 4.1). Consequently, most energy required for thermal comfort of aged care residents in Hobart is used for heating.

Winds are predominantly northwesterly throughout the year, except on summer afternoons when a sea-breeze frequently blows from the southeast (Linacre and Hobbs 1977: 183). The most common winds associated with a temperature lower than 10°C are from the northwest, south and southwest in the speed range 1-16 km/h (BoM 1979: 11). In the summer months, northwesterly winds, commonly with speeds of 17-32 km/m can result in temperatures above 30°C (BoM 1979: 11).

It was assumed that there were no differences between the four Tasmanian aged care organisations in terms of weather conditions. Meteorological data used in this study were measured by the Bureau of Meteorology at its station in Ellerslie Road, Hobart.

4.1.2 Site Descriptions

The four aged care organisations in Hobart that participated in this study are shown in Table 4.1 and the location of each organisation is shown in Figure 4.2. The identities of the organisations have not been linked to data in the Results and Discussion sections to ensure their confidentiality.

Name of aged care organisation	Address
1. Glenview Home	306 Main Rd, Glenorchy
2. St Ann Home	142 Davey St, Hobart
3. Freemasons Home	7 Ballawinne Rd, Lindisfarne
4. Lillian Martin Home	275-283 Cambridge Rd, Mornington

TABLE 4.1
Addresses of participating aged care organisations

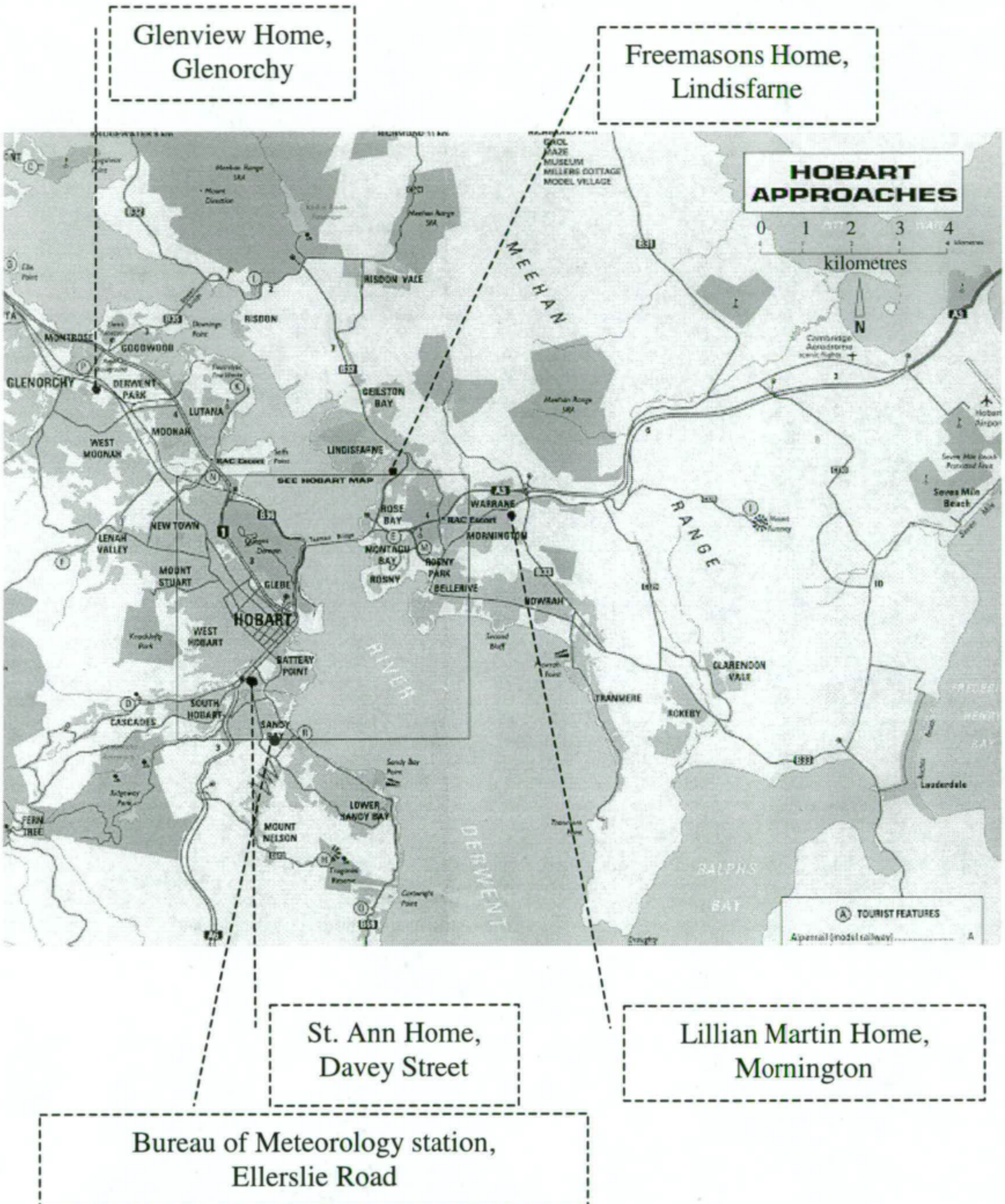


FIGURE 4.2

Map of the Hobart area showing locations of participating aged care organisations and the Bureau of Meteorology station (adapted from Department of Environment and Land Management 1997)

4.1.2.1 Glenview Home

Glenview home is situated to the north of Hobart in Glenorchy (Figure 4.2). The original Glenview home dates back to 1880, when it was built by Joseph Cook for a family home. It became an aged care home in 1948 for 20 residents, and new wings were progressively added since then (Table 4.2). In 1994 the kitchen, laundry, and office areas were extended and refurbished. Since 1995 the home has included a total of 101 beds, and it now has dual registration for 60 hostel and 41 nursing clients in the frail elderly and terminally ill categories. Locations of wings for Glenview's buildings are shown in Figure 4.3, and photographs of some of Glenview's buildings are shown in Figure 4.4. Glenview home is about to embark on further additions (new building for nursing residents) and a major upgrading program covering the entire complex. This program should be completed by 2001.

Wing Name	Year Built	Number of storeys	Total floor area (m^2)	Number of residents
Original Glenview Home (areas included, hostel rooms, office, kitchen, laundry)	1880	2	1,400	4 hostel residents
Hudspeth	1953	1	240	8 hostel residents
Thirkell	1957	1	300	7 hostel residents
Purvis & Barrett	1960	2	500	7 hostel residents 14 nursing residents
Kremmer	1963	1	400	13 nursing residents
Stella Thirkell	1983	1	250	4 nursing residents
Bisdee	1989	1	250	10 nursing residents
St John & Norah Renney	1995	2	1420	34 hostel residents

TABLE 4.2
General descriptions of Glenview's buildings

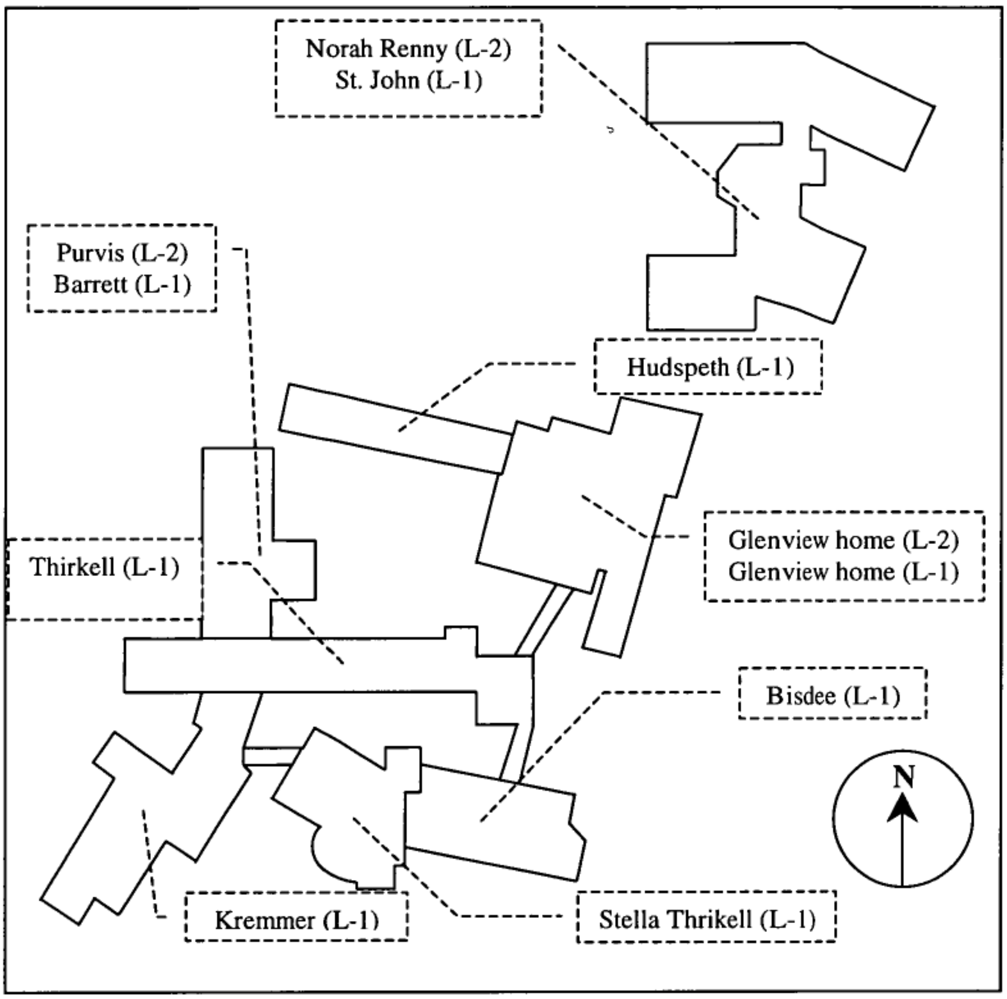


FIGURE 4.3
Glenview Site (schematic view, non scale).
L-1 = first floor wings, L-2 = second floor wings.

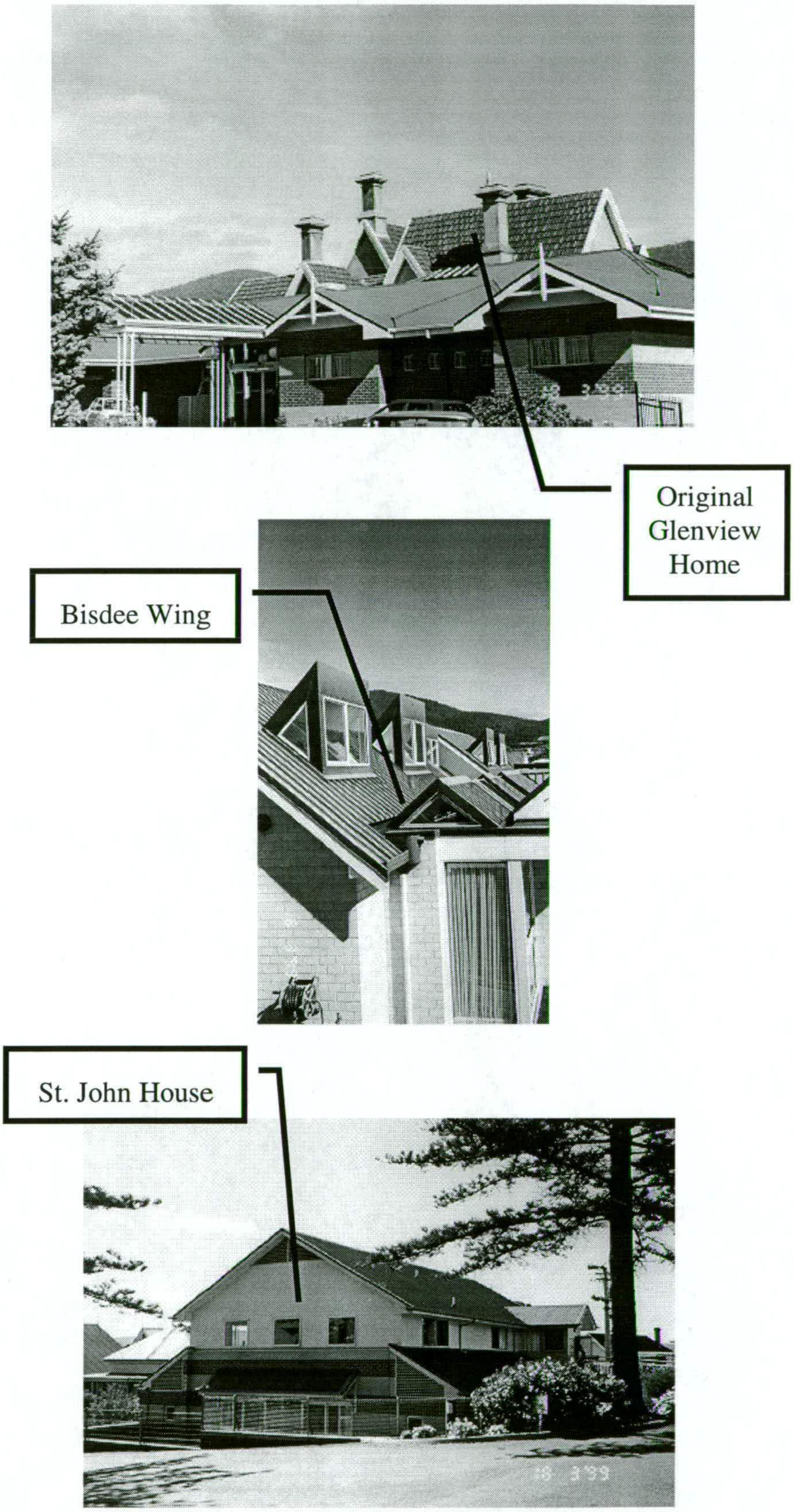


FIGURE 4.4
Photographs of Glenview's buildings

4.1.2.2 St Ann Home

St Ann home is situated on Davey Street approximately two kilometres from the Hobart city centre (Figure 4.2). It was established in 1948 and extensions were undertaken in 1951, 1959, and 1964. By 1991 further accommodation was provided with the construction of the new Davey, Townley, and Fitzroy wings. A new Laundry and Workshop building was also built at this time. In 1997, modifications were made to the kitchen. The current capacity of this home is 108 elderly residents. Some sections of the building are three storeys high, and these parts are serviced by two lifts. Locations of wings for St Ann's buildings are shown in Figure 4.5, and photographs of some of St Ann's buildings are shown in Figure 4.6.

The nursing home provides accommodation for 61 residents. There are 41 single rooms and nine shared rooms. Most have en-suite toilets and hand basins and thirteen have full en-suite facilities. An electronically secured door system in one section of the home provides added security for residents whose condition may cause them to wander unsafely away from the premises.

The hostel provides single room accommodation for 47 residents. All rooms have full en-suite facilities, some being shared with another resident. Kitchen areas are provided on both levels.

Wing Name	Total floor area (m^2)	Number of residents
Old Davey (areas included office, staff areas and kitchen)	1,030	
New Davey	1,350	16 nursing residents 21 hostel residents
Townley	1,600	19 nursing residents 26 hostel residents
Fitzroy	1,300	26 nursing residents
Laundry and Workshop	190	

TABLE 4.3
General descriptions of St Ann's buildings

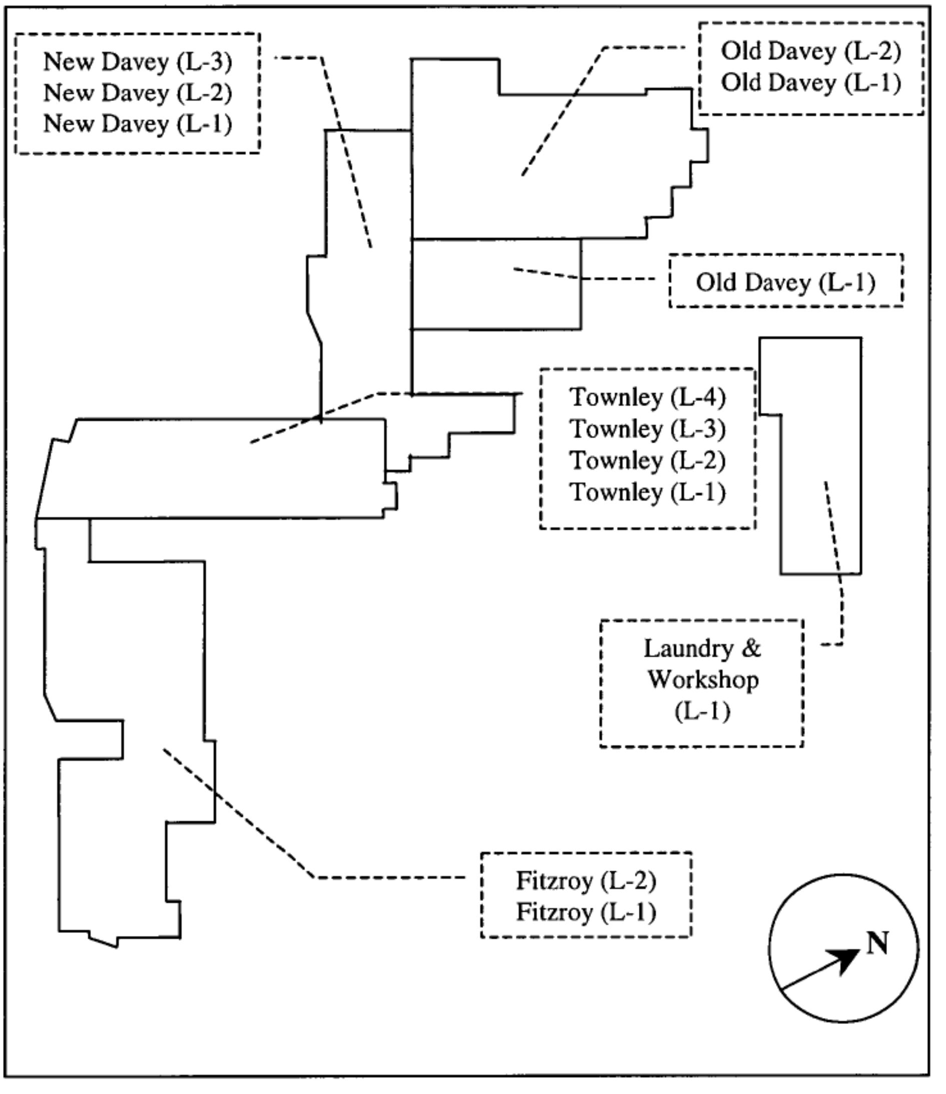
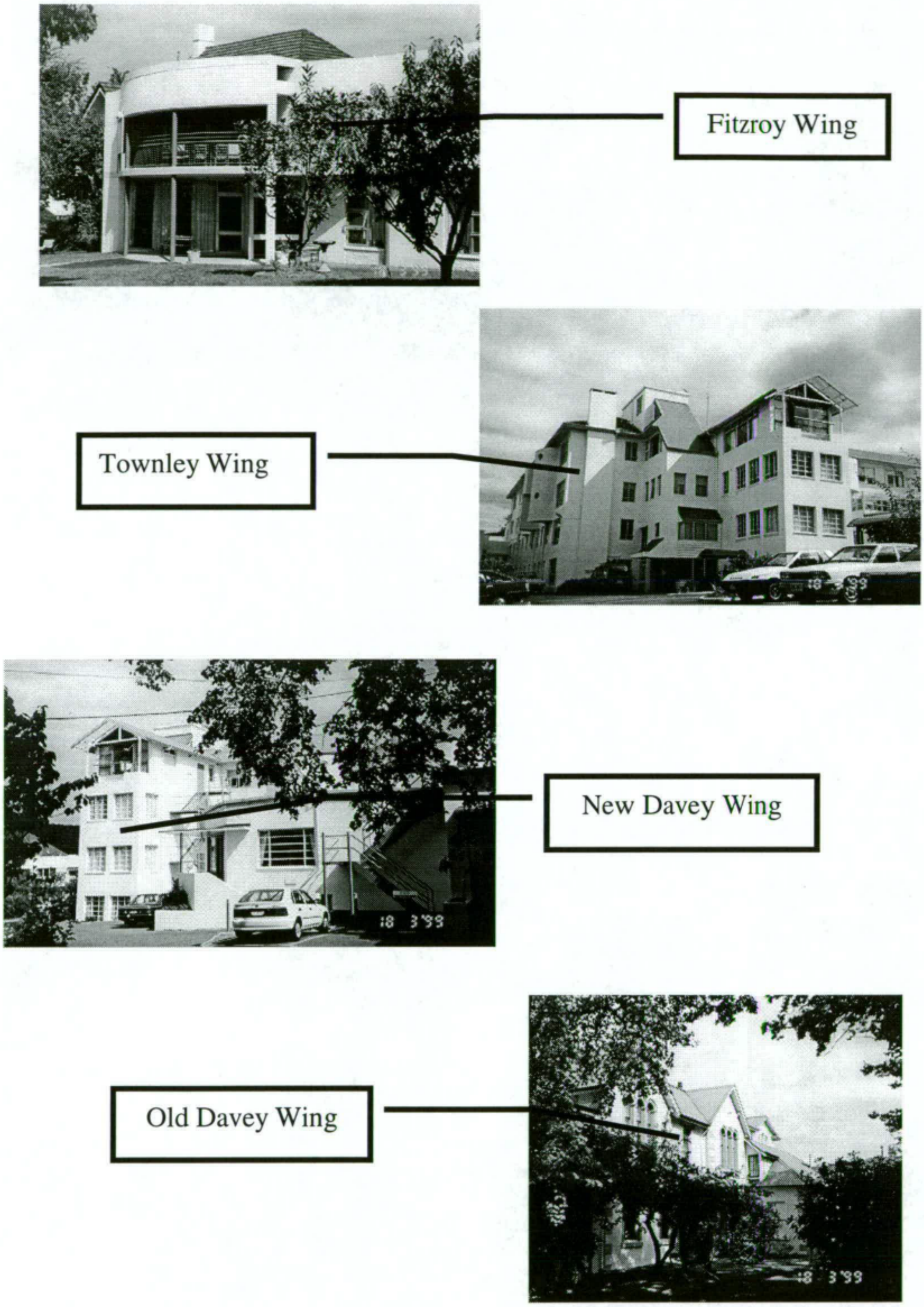


FIGURE 4.5
St Ann Site (schematic view, non scale)
L-1 = first floor wings, L-2 = second floor wings, L-3 = third floor wings, L-4 = forth floor wings.



<u>FIGURE 4.6</u>
Photographs of St Ann's buildings

4.1.2.3 Freemasons Home

Freemasons home is situated to the East of Hobart in Lindisfarne (Figure 4.2). It provides care to 122 aged citizens. It has dual registration for 59 nursing and 63 hostel residents.

These buildings were constructed specifically as a nursing home. The organisation's maintenance officer has no records of when the home was first established or its early history. However, records of building modifications since 1995 were available. Between 1995 and 1997, modifications were made to some parts of the Freemasons's buildings. In 1995 the existing washing machines were replaced with new commercial washing machines, and existing electric tumble dryers were replaced with new gas fired tumble dryers. In 1996, the existing electric hot water systems for kitchen and laundry were replaced with new gas hot water systems. A new kitchen was built in December 1997, which uses gas for cooking. Locations of wings for Freemason's buildings are shown in Figure 4.7, and photographs of some of Freemason's buildings are shown in Figure 4.8.

Wing Name	Number of storeys	Total floor area (m^2)	Number of residents
Waring & Quigley Annexe, Voss, and Griffith	3	2,000	23 nursing residents 20 hostel residents
Challender, and Linton	2	800	12 nursing residents 10 hostel residents
Johnson, and Gifford	2	1,000	14 nursing residents 16 hostel residents
Biggins (areas included office, laundry, kitchen, and nursing residents' room)	1	900	10 nursing residents
Mason	1	700	17 hostel residents

TABLE 4.4
General descriptions of Freemasons's buildings

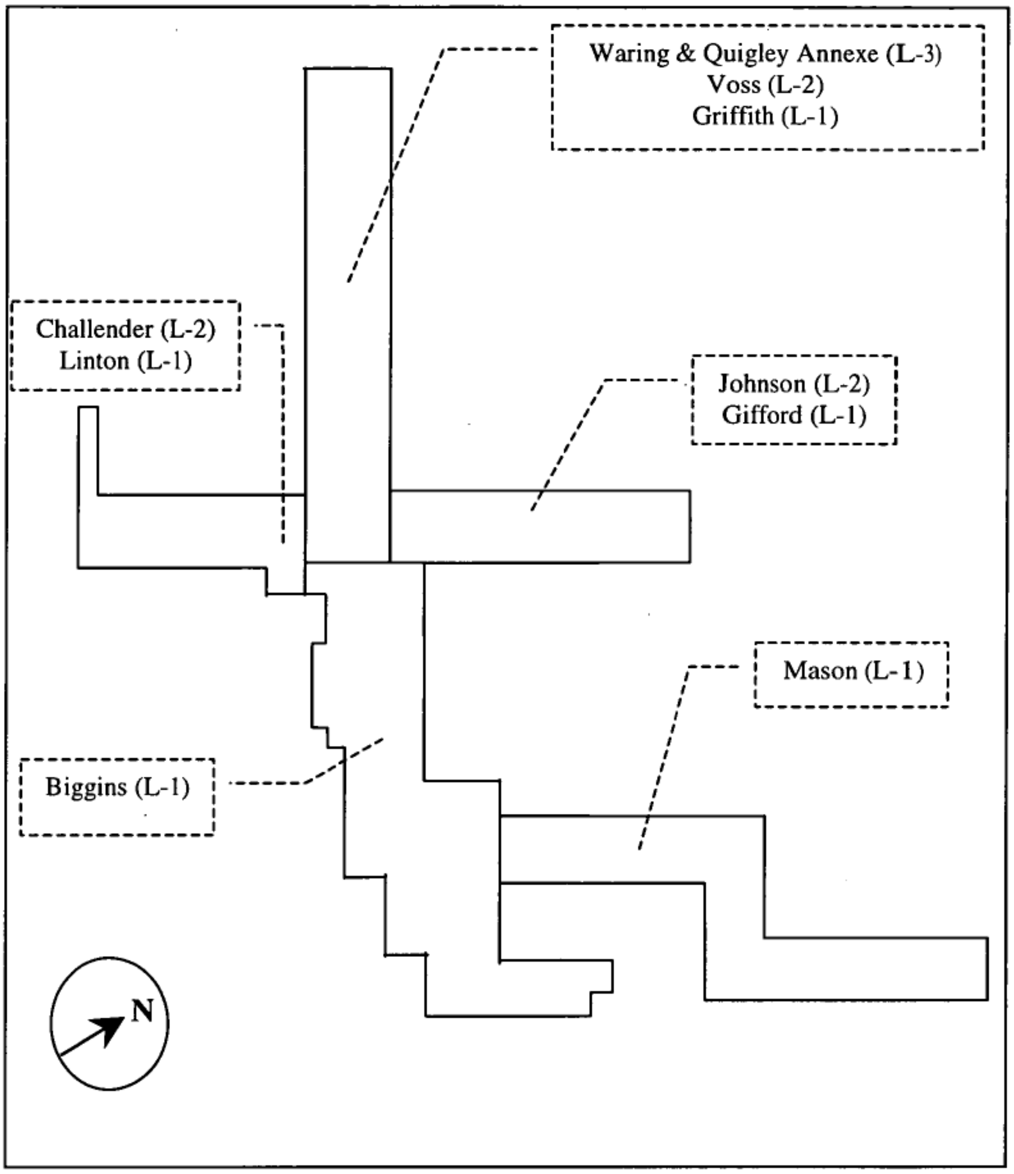


FIGURE 4.7
Freemasons Site (schematic view, non scale)
L-1 = first floor wings, L-2 = second floor wings, L-3 = third floor wings.

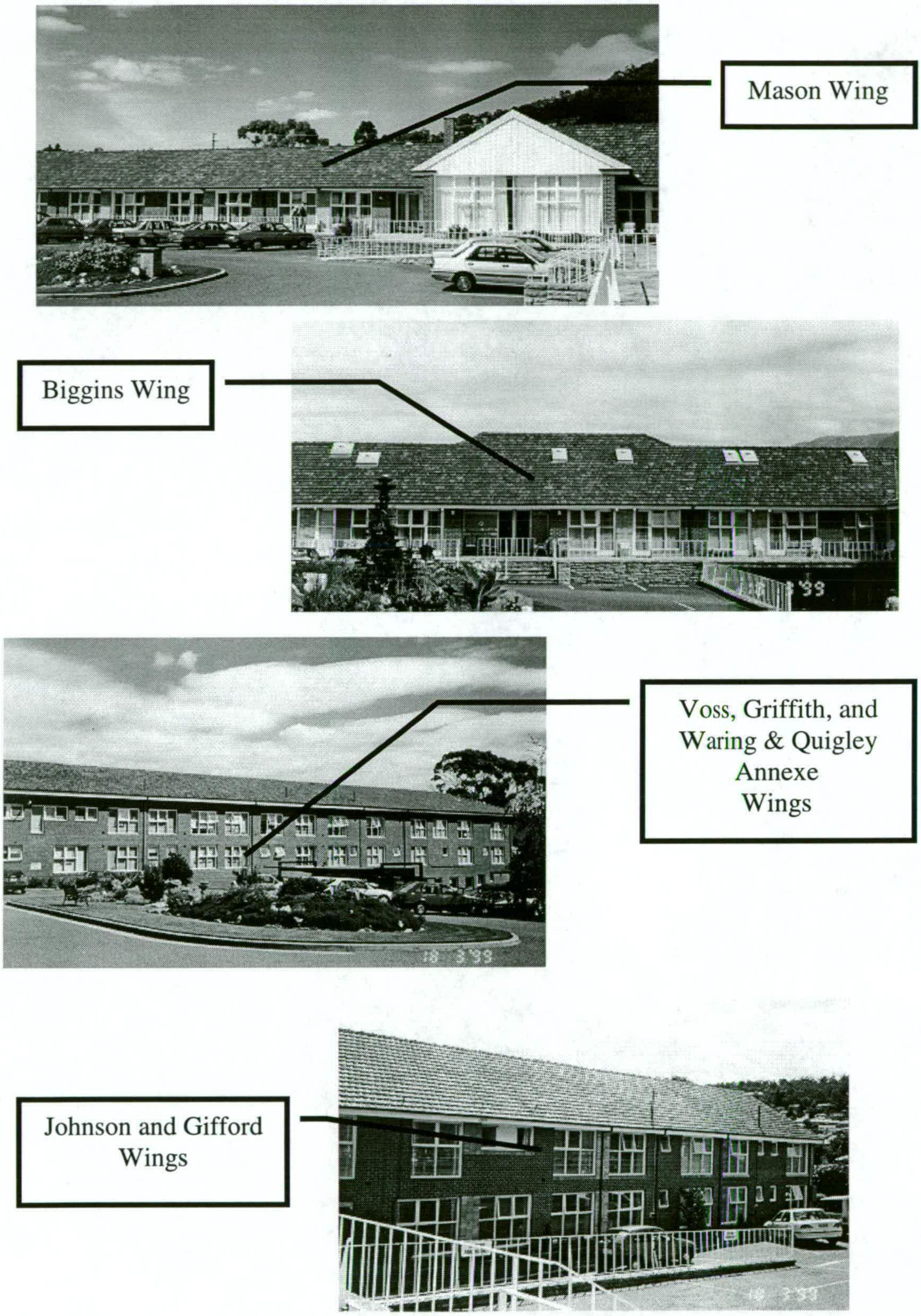


FIGURE 4.8
Photographs of Freemasons's buildings

4.1.2.4 Lillian Martin Home

Lillian Martin home is situated to the east of Hobart in Mornington (Figure 4.2). It provides aged care to 93 residents. The nursing home provides single room accommodation for 41 residents and the hostel provides both single room as well as shared room accommodation for 52 residents. The building is two storeys in parts and is serviced by a lift and a chair lift. The oldest buildings were erected in 1971 to be a nursing home (Table 4.5). All of the remaining wings were constructed before 1980, apart from the Waratah wing which was built in 1996 (Table 4.5). Locations of wings for Lillian Martin's buildings are shown in Figure 4.9, and photographs of some of Lillian Martin's buildings are shown in Figure 4.10.

Lillian Martin home is about to embark on a major lighting globe upgrading program covering all parts of buildings that were constructed before 1980. All the existing incandescent globes will be replaced with compact fluorescent globes and fluorescent tubes. This program should be completed by the year 2000.

Wing Name	Year Built	Number of storeys	Total floor area (m^2)	Number of residents
Administration areas (nursing and staff areas, dinning rooms, office, kitchen, and laundry)	1971	1	1460	
Dryden Thomas	1971	1	160	4 hostel residents
Isobel Green	1971	1	520	12 nursing residents
Marbel Bell Green	1971	1	310	8 nursing residents
Silberisen	1971	1	710	17 nursing residents
Bell Thomas E.R. Henry	1979	2	900	24 hostel residents
Chester Gifford	1979	2	520	12 hostel residents
Waratah	1996	2	1220	12 hostel residents 4 nursing residents

TABLE 4.5
General descriptions of Lillian Martin's buildings

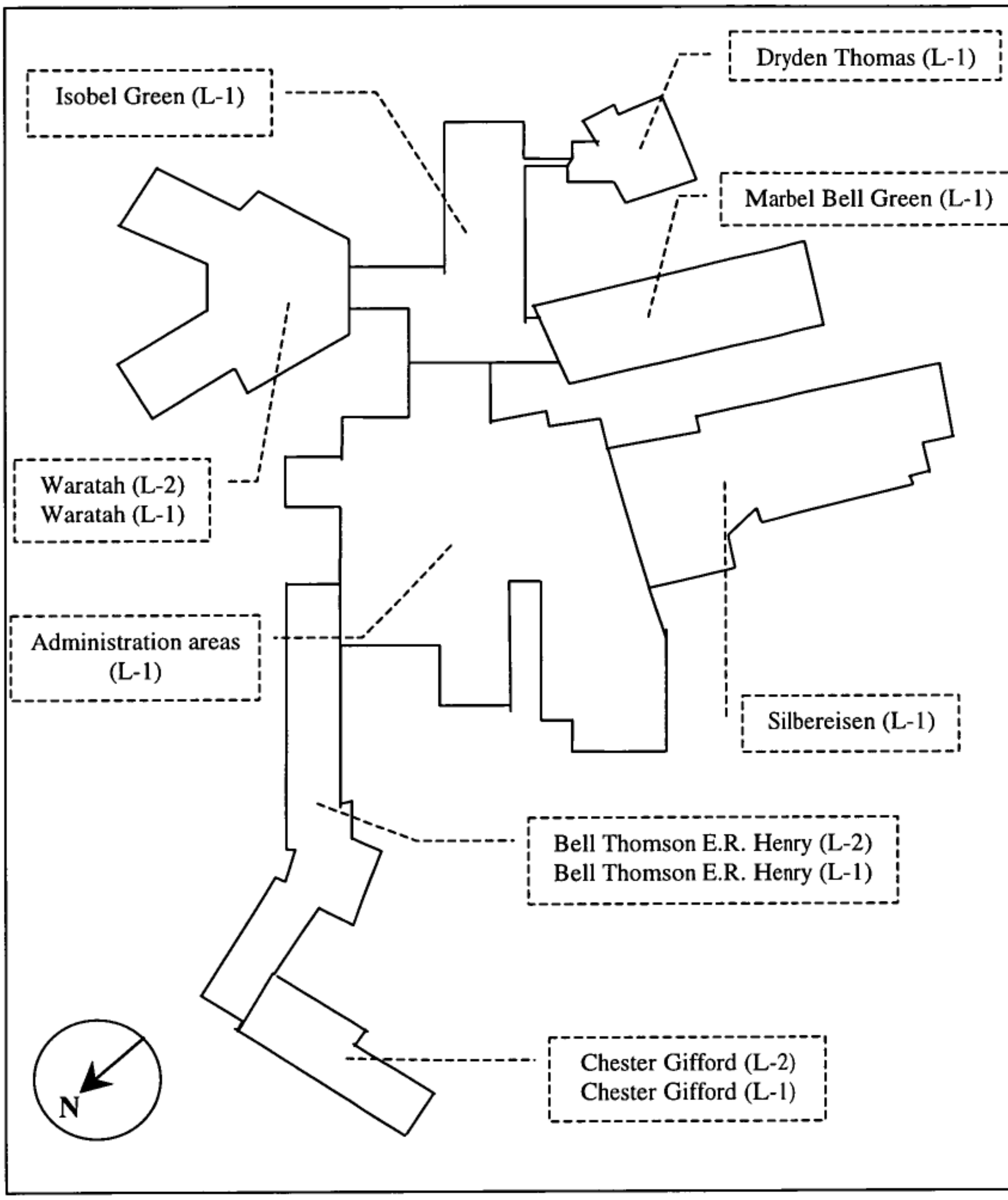


FIGURE 4.9

Lillian Martin Site (schematic view, non scale)

L-1 = first floor wings, L-2 = second floor wings.

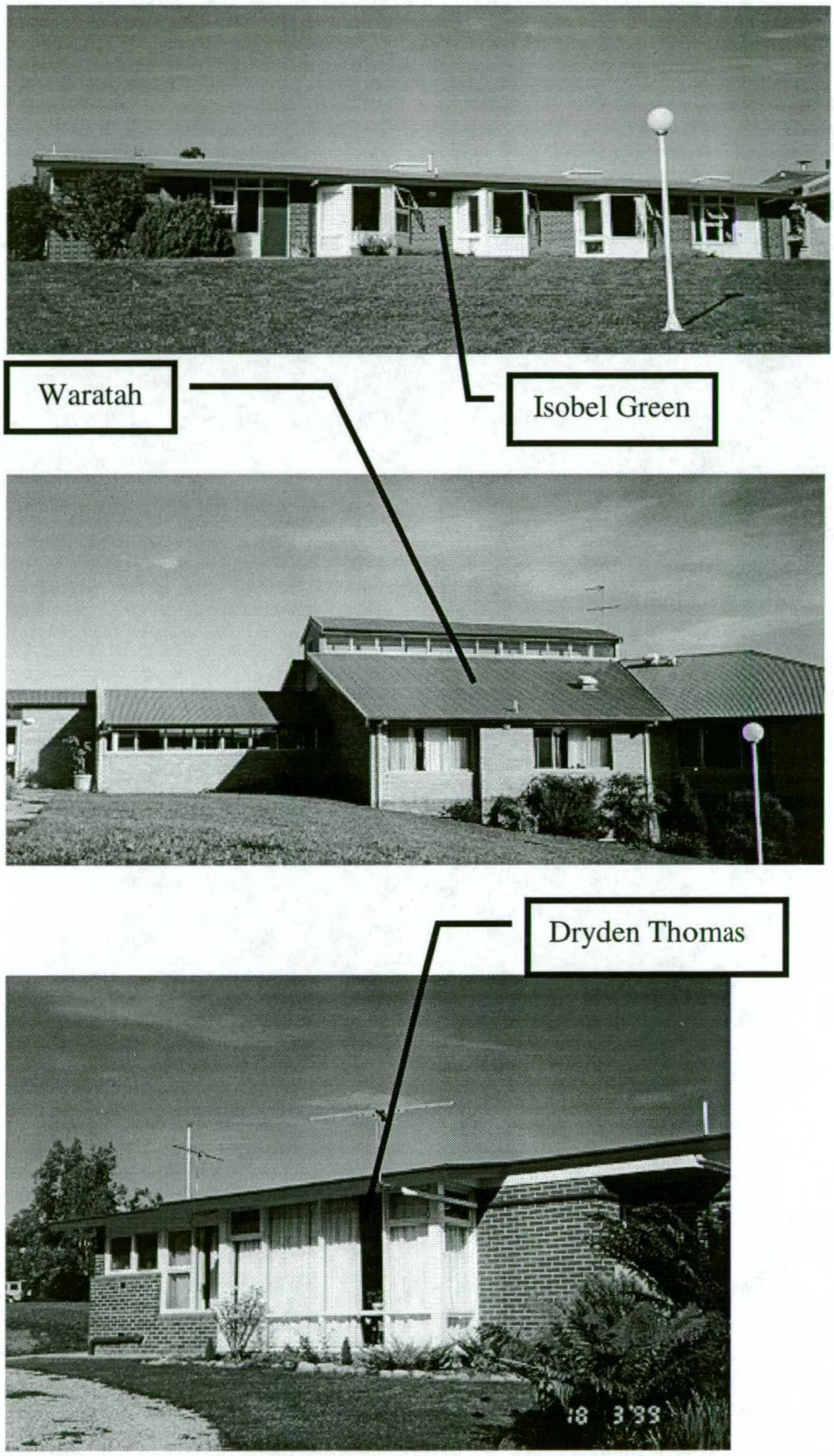


FIGURE 4.10
Photographs of Lillian Martin's Buildings

4.1.3 Methodology

This study investigated energy performance for Tasmanian aged care buildings by conducting energy audits in the four old people's homes in Hobart. It was assumed that these homes have energy performance features typical of aged care organisations in the state of Tasmania. Moreover, the study attempted to assist these organisations in understanding the ways energy is used in their buildings, identified areas of energy waste and inefficiency, and potential for improvement. Hence periodic progress reports from the energy audits have been given to each individual organisation throughout the study.

The four organisations provide 3 levels of aged care services. These are accommodation, hostel level care, and nursing level care services. However, energy audits were only conducted in the main buildings of each organisation, which are the areas for all hostel and nursing residents, staff rooms, administration office, nursing stations, dining rooms, communal rooms, recreation rooms, church, bathrooms and toilets, laundry, and kitchen. The main buildings in each organisation have three separate electricity meters i.e., residential light and power, institutional hot water, and winterpac off-peak. The areas for accommodation residents were not investigated because these areas are similar to normal residential houses in having their own electricity meters.

The three stages of energy audits described in Chapter 2 (stage 1 - preliminary audit; stage 2 - walk-through audit; and stage 3 - detailed audit) were used in this study. Step 1 of the preliminary audit and the walk-through audit were concurrently conducted at each site between November 1998 and January 2000. Step 2 of the preliminary audit and the detailed audit were conducted immediately after that, at the University of Tasmania. The methodology of energy audits at each stage and the uses of energy audit equipment are described below.

4.1.3.1 Stage 1 - Preliminary audit

➪ Step 1 - Analysis of historical energy records and establishing trends

Historical energy data, in the form of energy consumption and costs detailed in electricity, LPG, and fuel wood bills, were collected for each organisation. Electricity data were obtained for the past three years, while LPG data were only collected for the past year because some organisations only kept LPG records for one year. Electricity bills were sent on a regular basis every 3 months, whereas LPG was purchased on numerous occasions each month whenever the supply cylinder was emptied. Consumption units used for the electricity are kilowatt-hours (kWh) while those for LPG are litres (L). Hence, the consumption units for LPG were converted to the same unit in kWh. Fuel wood was used in only one organisation. Firewood (air dry) was purchased once a year and the consumption units used are tonnes (t). The consumption units used for fuel wood were also converted to kWh.

➪ Step 2 - Estimation of energy savings potential

Annual energy consumption indices in kWh/m^2 for each aged care building were calculated using the Microsoft Excel spreadsheet program. The Tasmanian aged care energy consumption index was defined as the average energy consumption per floor area of the four aged care organisations. The Tasmanian energy consumption index was then compared to the UK annual energy consumption standard of less than 172 kWh/m^2. If the Tasmanian index met the UK standard, it was then compared with the Danish average annual standard of 124 kWh/m^2.

4.1.3.2 Stage 2 - Walk-through audit

The walk-through audit can be separated into three parts: pre-audit visits; audit surveys; and audit measurements.

➪ Pre-audit visits

For the purpose of familiarisation with the four aged care buildings, two or more pre-audit visits at each site were conducted concurrently with the preliminary audit stage. Other related information including: building plan (schematic), area, age, upgrading history; number of residents; and energy concerns in the organisations were obtained during the pre-audit visits by interviewing aged care managers and staff at each site. Some organisations were able to provide all information required while others were not. When the organisation was unable to provide information relating to the building layout, floor areas were measured during the walk-through audits.

➪ Audit surveys

Walk-through surveys were used to investigate the areas inside and outside the main buildings in each aged care organisation. The surveys were conducted several times at each site. The conditions of building components such as walls, roofs, curtains or blinds, pelmets, internal and external doors, windows and window frames were recorded during the surveys. Energy or electrical appliances used inside and outside the buildings were also inspected for type and condition. This included heating systems, hot water systems and their insulation, lighting systems, and other office, kitchen, and laundry appliances. The capacities of mains pressure hot water cylinders were inspected and recorded, except for Organisation C where they were locked inside cupboards. The capacities of the low pressure hot water cylinders were not inspected because the tanks were located in the roofs. Photographs of buildings and some energy appliances in each aged care building were taken using an automatic camera (Pentax ESPIO 738).

➪ Audit measurements

After completing the audit surveys, the following building characteristics relevant to energy consumption were measured. The methodologies and equipment used in audit measurements are detailed below.

1) Measuring building dimensions and orientations

For organisations that were unable to provide information on building layouts and floor areas, this information was obtained by taking on-site measurements. A 50 metre measuring tape was used to determine external building widths and lengths, and a compass was used to ascertain building orientations. This allowed the floor area to be calculated and, in conjunction with the historical energy consumption data, the Tasmanian energy consumption index in kWh/m^2 to be determined.

2) Measuring ceiling heights

At all aged care organisations, the heights between floors and ceilings in each room were determined using an eight metre measuring tape. From this, an average ceiling height in each building was calculated.

3) Measuring insulation thickness above ceilings

Insulation materials above ceilings were inspected by climbing up a ladder into a manhole with a torch. The types of insulation materials present were noted, and the bulk insulation thickness was measured using a 30 cm ruler with 1 mm gradations.

4) Measuring light intensity

Light power is measured in lumens and illumination is measured in lux, with one lux being equivalent to one lumen per square metre (Vorsatz 1996: 13). Illumination depends on how lighting power is diffused. If 1000 lumens is diffused over 1 square metre the resultant illumination is 1000 lux, but if 1000 lumens is diffused over 10 square metres the resultant illumination is only 100 lux (Energy Victoria 1994: 21).

An EMTEK LX-101 lux meter was used to measure light intensity in many areas of aged care organisations. The sensor was held by hand horizontally at waist height while standing directly beneath the light source. Measurement taking was limited to daylight hours because it was not possible to access the buildings at night due to security reasons for the organisations.

By comparing this light intensity with that recommended for Australia and other countries it was possible to determine whether they were over-lighting their areas. However, since most residents in aged care organisation were suffering from poor eyesight, illumination in some areas of an aged care organisation may need to be slightly higher than the recommendations.

5) Measurements of air leakage around vented skylights

An airflow anemometer (wind velocity TA 3000) was used to measure airflows passing through vented skylights. The sensor was held by hand for 5 minutes vertically as close to the gap as possible. During this time the wind speed displayed by the anemometer was observed constantly, and then an average wind speed was estimated. The volume of air leaking per unit time was calculated by multiplying the average wind speed by the area of the gap.

6) Measurements of air temperatures

Measurements of a building's air temperatures over a period of time can indicate the effectiveness of heating operations of that building as well as the thermal comfort levels of the residents. Temperature recording machines operated by a laptop computer were set to measure and record air temperatures every 30 minutes for between one and two weeks. At each site investigated, temperature loggers were fixed concurrently to the wall both inside and outside the buildings. The temperature data recorded by the machines were imported to the Microsoft Excel 97 program for analysis.

The temperature recording machines used were: an electronic data recorder from the Dataflow Systems Pty Ltd, called 'Dataflow recorder' (Model 692/DS93) operated with Dataflow Software Version 4.96 (one aged care organisation only); and five temperature loggers made by Onset Computer Corporation, called 'HOBO 2K loggers' operated with BoxCar Pro software (all four organisations).

Dataflow recorder Model 692/DS93 can be used to monitor a variety of parameters such as temperature, humidity, wind speed and direction, and soil moisture by using different sensor types. However, in this study, the dataflow recorder was used only for air temperature measurements. The Dataflow recorder is composed of a multi-channel data recorder and six batteries housed within a 20 cm × 25 cm × 8 cm weatherproof plastic box. It is essential to have a desiccator inside the weatherproof box because moisture may cause permanent irreparable damage to the recorder. Therefore, some silica gel satchels were placed inside the weatherproof box. The data recorder had eight 5 metre cables attached, each of which connected to a temperature sensor. The data recorder was operated by the dataflow software in a laptop computer connected via a computer-port. The computer programme controlled the starting and finishing times, and period of time between temperature measurements, calibrated the temperature sensor, and downloaded temperature data into the computer. This provided a digital output to two decimal places. Relative temperature measurement accuracy was estimated at ±0.2°C and absolute at ±0.5°C.

The eight temperature probes on the data recorder were calibrated against a reference and tested before using to take temperature measurements in one aged care organisation. It was found that one sensor always gave erroneous temperature readings. Therefore, the error sensor was marked not to be used; and measurement taking was limited to the other seven probes. The seven cables with temperature probes were installed into four different places which are: two probes on the outside wall of the building, 1.5 metres above the ground; two probes on the ceiling; two probes on the interior wall at 1.5 metres from the floor; and one on the floor inside the building. Adhesive insulation tape was used to attach the seven cables to the ceiling, wall, and floor surfaces while the temperature probes were suspended in the air. However, for security reasons, all windows and doors in residential rooms have to be kept firmly closed at night. Hence, there were no gaps through which the two cable probes could pass to the outside of the building. To overcome this, the recorder was once placed in a small laundry and twice in toilets so that the cables could pass through the ventilation gaps to outside the building. However, the other five cables were not long enough to reach from the laundry, or one of the toilets, to a residential room. Hence measurements of internal air temperatures were limited to the nearby corridors for two sites.

Because of the limited capacity of the Dataflow recorder to access the internal and external parts of the building simultaneously, it was decided not to use this equipment for the other three aged care organisations. Measurements of air temperatures were suspended temporarily until five HOBO 2K loggers were obtained. These were then used to measure air temperatures in all four aged care organisations.

The HOBO 2K logger is a portless matchbox-sized machine. Due to its light weight, a single logger can be attached to a wall or a door easily with adhesive. One HOBO 2K logger contains one temperature sensor and a battery inside the plastic cover. The logger has a computer port for connecting with a laptop computer and is operated by its own software. However, unlike the dataflow recorder, the HOBO 2K logger can not set the starting or finishing time for a measurement. The first temperature measurement is started as soon as the command was launched from the computer and the last measurement is stopped as soon as the data is downloaded into the computer. A tiny light bulb starts blinking after a logger is set, indicating that the logger is now properly operating. The temperature data from the HOBO 2K logger can only be read to 0.3°C. However, it is accurate enough for this study.

The HOBO 2K loggers were used to record internal and external temperatures concurrently in each aged care organisation. All readings were taken 1.5 metres above the floor or ground. Two of the organisations had a wide variety of building conditions and heater types. For both of these, all five loggers were used. The loggers were attached on the interior walls of four residential rooms with different thermal characteristics, and one on the outside wall of the building. Each of the other two organisations had uniform thermal characteristics. Hence, only two loggers were used at one organisation (one logger outside the building, and one logger inside a residential room), and three loggers used at the other (one logger outside the building, and one logger in each of two residential rooms).

Despite attempts to place the loggers away from direct sunlight, one of the outdoor loggers did receive direct sunlight in the afternoon. As a result, afternoon temperatures recorded by this logger were higher than the maximum air temperatures on sunny days. These false temperature data were adjusted by ignoring irregular spikes in the temperature which corresponded to sunny periods, and using maximum temperature data from the Bureau of Meteorology.

4.1.3.3 Stage 3 - Detailed audit

Results from the preliminary audits showed the energy consumption performance of the four aged care organisations. By comparing their energy consumption indices to those of the UK and Denmark best practice standards, the potential for improvement was determined. The information gathered from walk-through audits indicated which areas of energy use involved inefficiencies and, hence, where the greatest potential for energy saving lies. The energy saving measures most appropriate for these areas were chosen by reviewing information on energy case studies in other aged care organisations, energy efficient technologies, and energy codes or standards. In this study, the Payback Period and the Net Present Value (NPV) financial evaluation techniques were used to assess whether energy saving investments were economically viable. The payback period technique was chosen to be used because this technique can directly approximate the economic worth of an energy saving measure. It is also simple to understand for a manager or other staff who may not have a basic understanding of financial mathematics. For short term actions the risks of investing money are very low; hence the NPV was not used to assess these actions.

However, if any energy saving action had a medium- or long-term payback period (more than three years) then the NPV was used to assess this action. The Average Rate of Return (ARR) and the Internal Rate of Return (IRR) were not chosen to be used in this study because they are not simple to understand like the Payback Period, or good indicators of an investment like the NPV. Hence, an implementation plan for Tasmanian aged care organisations to meet the overseas best practice energy standards was established.

Results from conducting the three stages of energy audits in the Tasmanian aged care organisations are presented in two chapters, Chapter 4 and 5. The results from step 1 of the preliminary audit and the walk-through audit are discussed in Section 4.2 Part 2: Results and Discussion Chapter 4. Results from step 2 of the preliminary audit and the detailed audit are discussed in Chapter 5: Comparisons and Recommendations.

4.2 PART 2: RESULTS AND DISCUSSION

This section presents and discusses the results derived from conducting step 1 of the preliminary audits and the walk-through audits in the four aged care organisations. This includes comparisons of energy performance between the four organisations. To ensure the confidentiality of the four aged care organisations as much as possible, they have been randomly allocated to the codes of Organisation A, B, C and D.

4.2.1 Results of Energy Audits in Four Tasmanian Aged Care Organisations

4.2.1.1 Step 1 of the Preliminary audits

This section discusses the results from the analysis of historical energy records carried out in four Tasmanian aged care organisations. Gas energy usage is discussed first followed by electricity and fuel wood.

Total monthly gas consumption throughout 1999 (Figure 4.11) differed significantly between organisations ($p<0.0001$) and months ($p=0.006$) (2-way ANOVA). Organisation C had the highest monthly gas consumption in 1999, followed by Organisations D, A, and B (Figure 4.11).

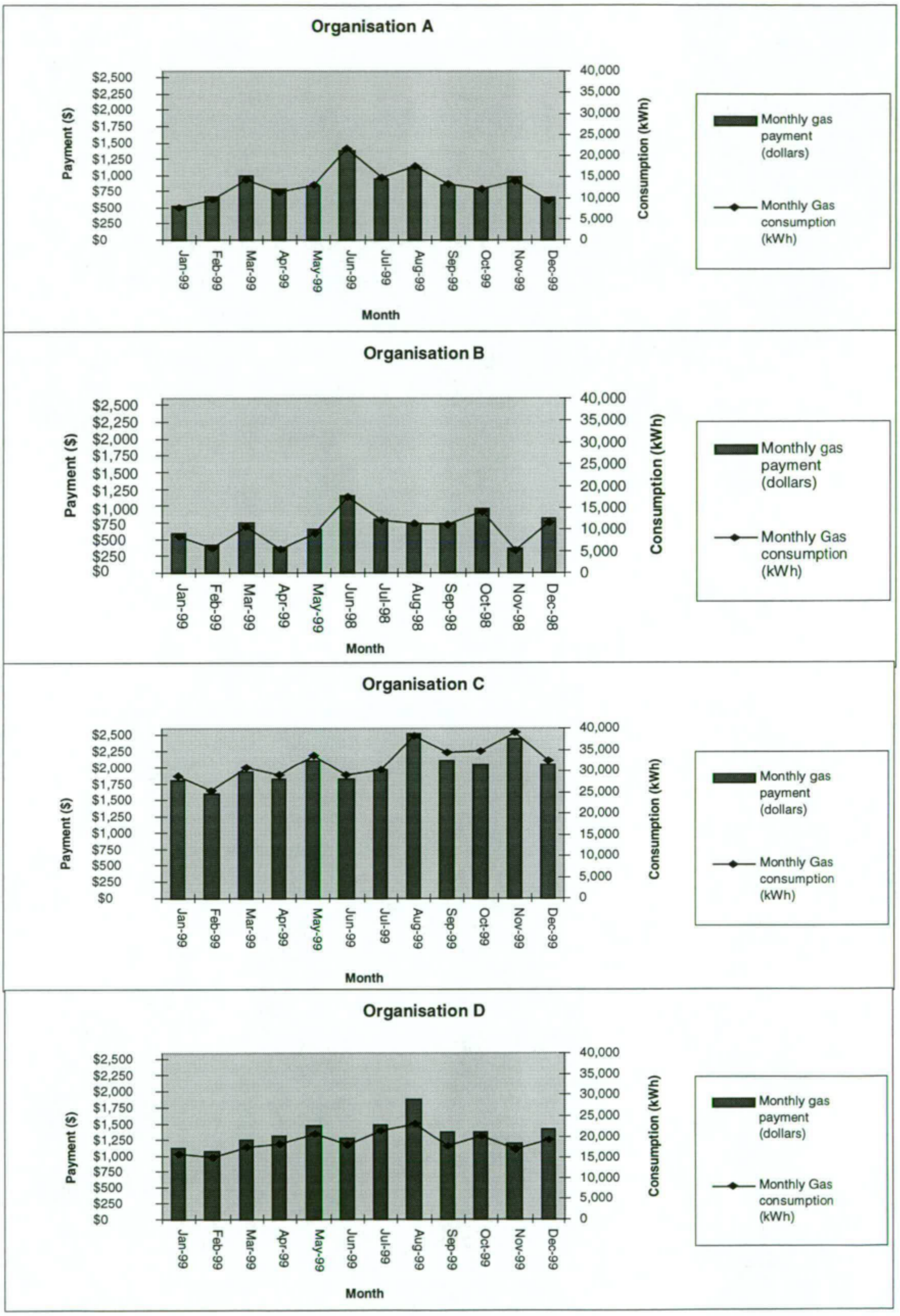


FIGURE 4.11

Monthly Gas payment and consumption in 1999 for the four aged care organisations

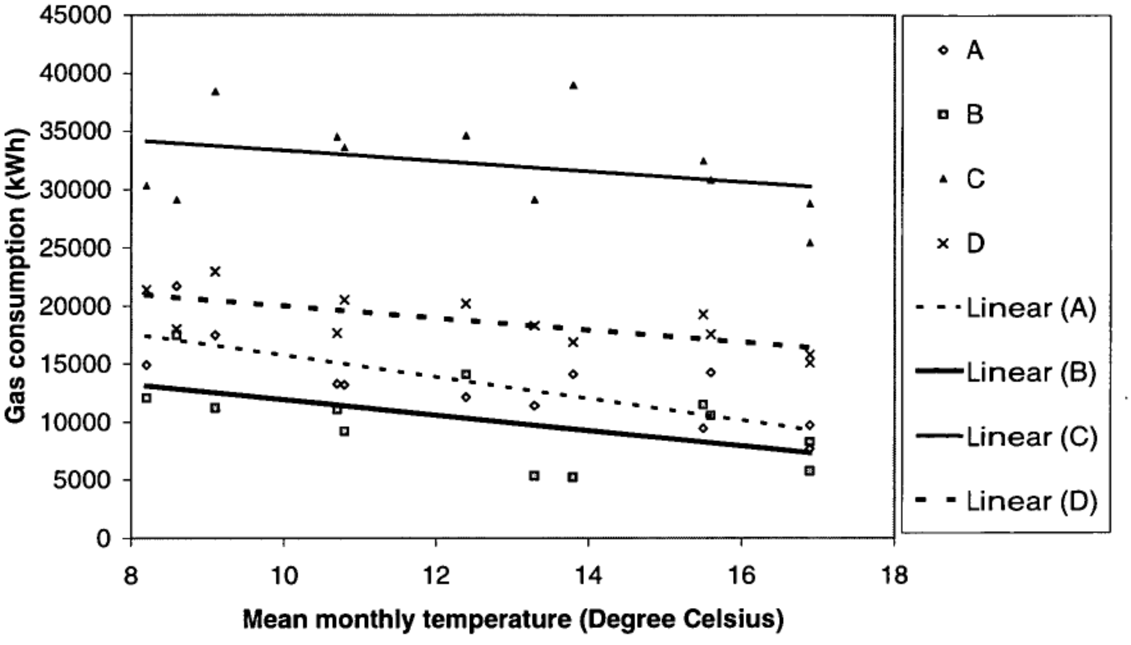


FIGURE 4.12
Monthly gas consumption during 1999 in each organisation as a function of mean monthly temperature in Hobart in 1999 (BoM 1999)

Organisation	Correlation	Slope of line	R^2
A	-0.78371	-932.15	0.6142
B	-0.57310	-663.74	0.3284
C	-0.35324	-450.36	0.1248
D	-0.71406	-524.34	0.5099

TABLE 4.6
Summary statistics of the relationships between monthly gas consumption during 1999 in each organisation and mean monthly temperature in Hobart in 1999 (BoM 1999)

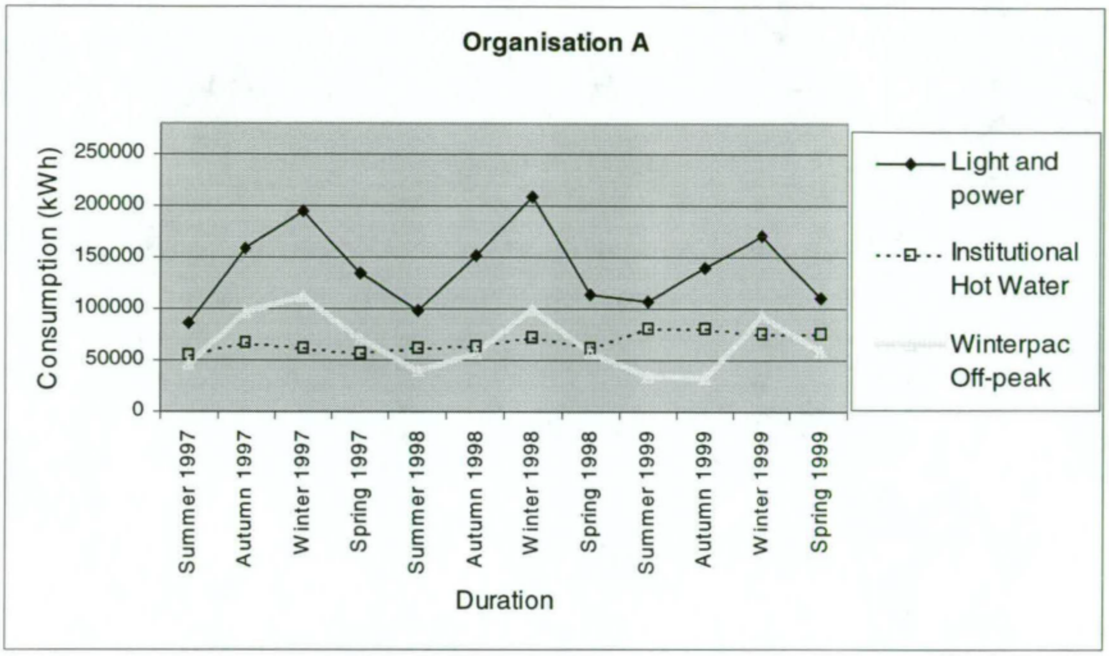
For all organisations, there was a trend for gas consumption to be negatively correlated with monthly air temperature (Figure 4.12). This relationship was greatest for Organisation A and weakest for Organisation C (Table 4.6).

There was strong seasonal variation in the levels of electricity consumption for light and power ($p<0.0001$) and for winterpac off-peak ($p<0.0001$) between 1997 and 1999 (2-way ANOVA with years as replicates). The highest consumption in both of these areas was in winter and the lowest consumption was in summer (Figures 4.13, 4.14, 4.15, and 4.16). The levels of consumption in both of these areas also varied significantly between organisations ($p<0.0001$) and the seasonal patterns of variation also differed between organisations ($p<0.0001$). For instance, seasonal fluctuations in electricity consumption in Organisation D were due to winterpac off-peak rather than light and power (Figure 4.16). In contrast, light and power electricity consumption for Organisation C varied greatly with the seasons while that for winterpac off-peak was always low, but still showed the same pattern (Figure 4.15). Organisations A and B both exhibited strong seasonal fluctuations in consumption in both of these areas (Figures 4.13 and 4.14).

In contrast to light and power and winterpac off-peak, periodic electricity consumption for institutional hot water in the four organisations did not depend upon the season ($p=0.283$, 2-way ANOVA with years as replicates) between 1997 and 1999 (Figure 4.13, 4.14, 4.15, and 4.16). There was also no relationship between seasonal patterns of electricity use for hot water and the various organisations ($p=0.931$). However, levels of consumption for hot water differed significantly between organisations ($p<0.0001$). Seasonal consumption for institutional hot water electricity for Organisation B and C were less than 50000 kWh, lower than the other two organisations (Figure 4.14 and 4.15). The consumption trend for Organisations A and B tended to increase slightly between 1997 and 1999, while that for Organisations C and D exhibited a slow decline. (Figures 4.13 to 4.16).

The total annual electricity consumption from 1997 to 1999 (Figure 4.17) differed significantly between the four organisations ($p=0.046$, 2-way ANOVA). However, the annual changes in total energy consumption within each organisation were not significant ($p=0.168$). In spite of this, the annual total electricity consumption decreased gradually from 1997 to 1999 for Organisation A and C and slightly decreased for Organisation D, while the consumption fluctuated for Organisation B (Figure 4.17).

The same patterns were evident for each of the components of electricity consumption. The consumption for each of light and power, institutional hot water, and winterpac off-peak differed significantly between the four organisations ($p<0.001$, 2-way ANOVA) but not between years ($p=0.910$, $p=0.972$ and $p=0.150$ respectively). Organisation C had considerably higher electricity consumption for light and power compared to other organisations, while Organisation D had notably low consumption compared to others (Figure 4.17). However, Organisation C had very low electricity use for winterpac off-peak compared to other organisations.



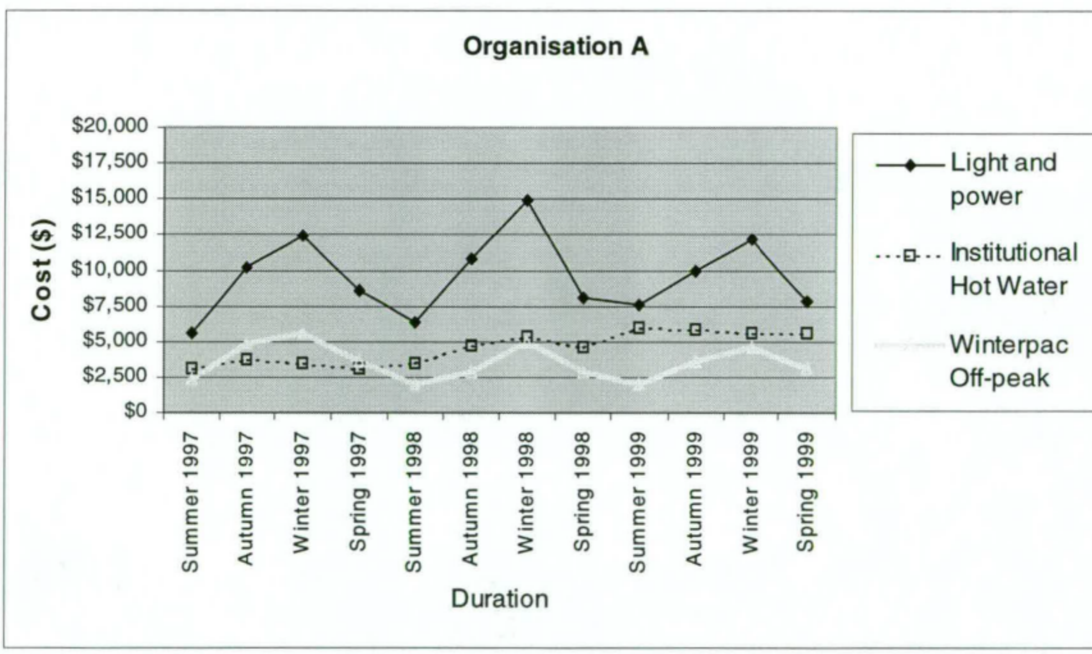
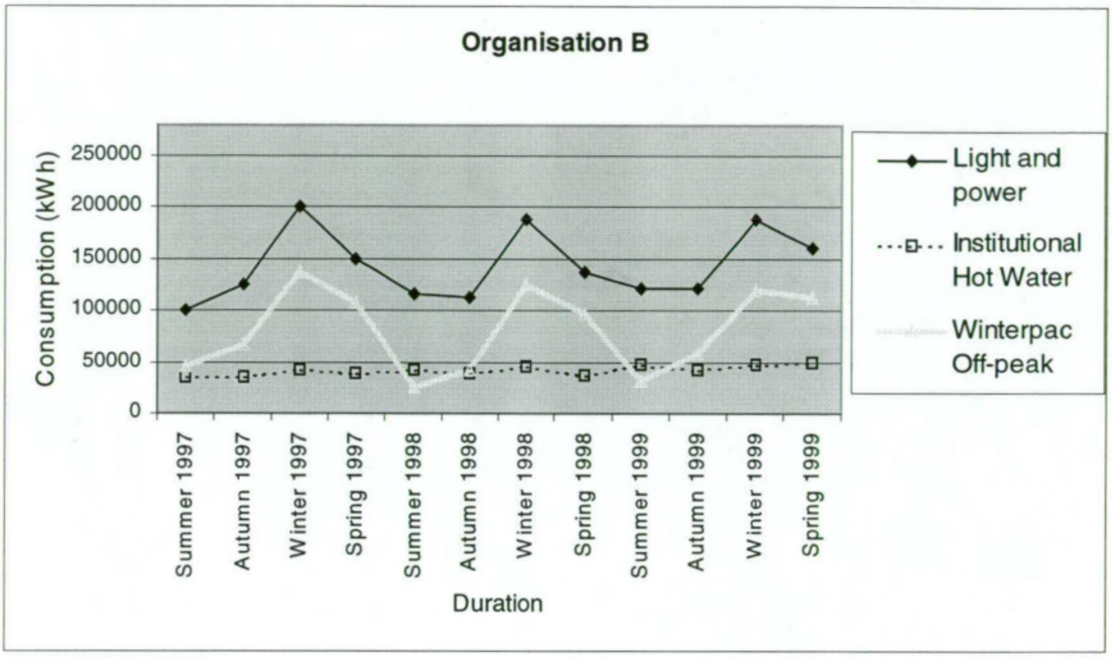


FIGURE 4.13

Periodic electricity consumption and payment for Organisation A between the years 1997 and 1999



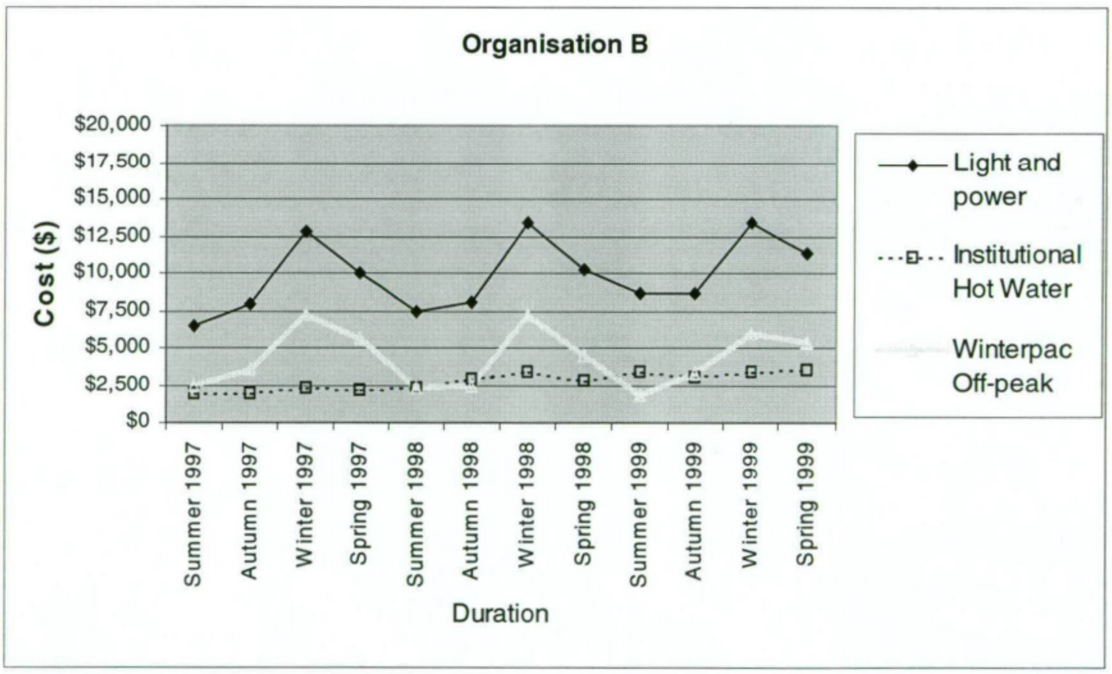
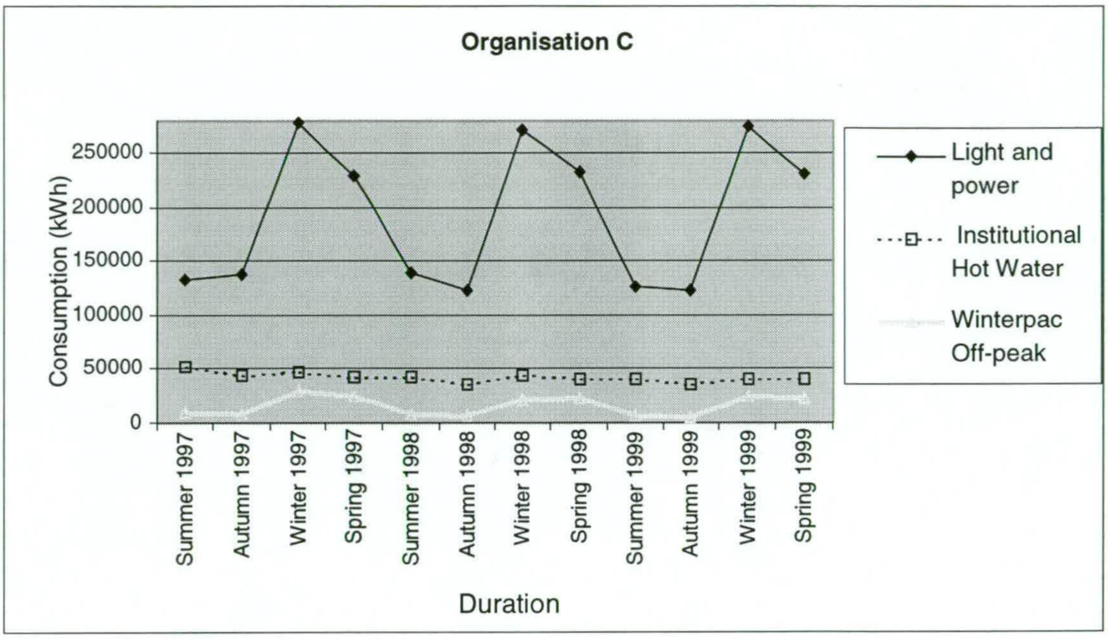


FIGURE 4.14

Periodic electricity consumption and payment for Organisation B between the years 1997 and 1999



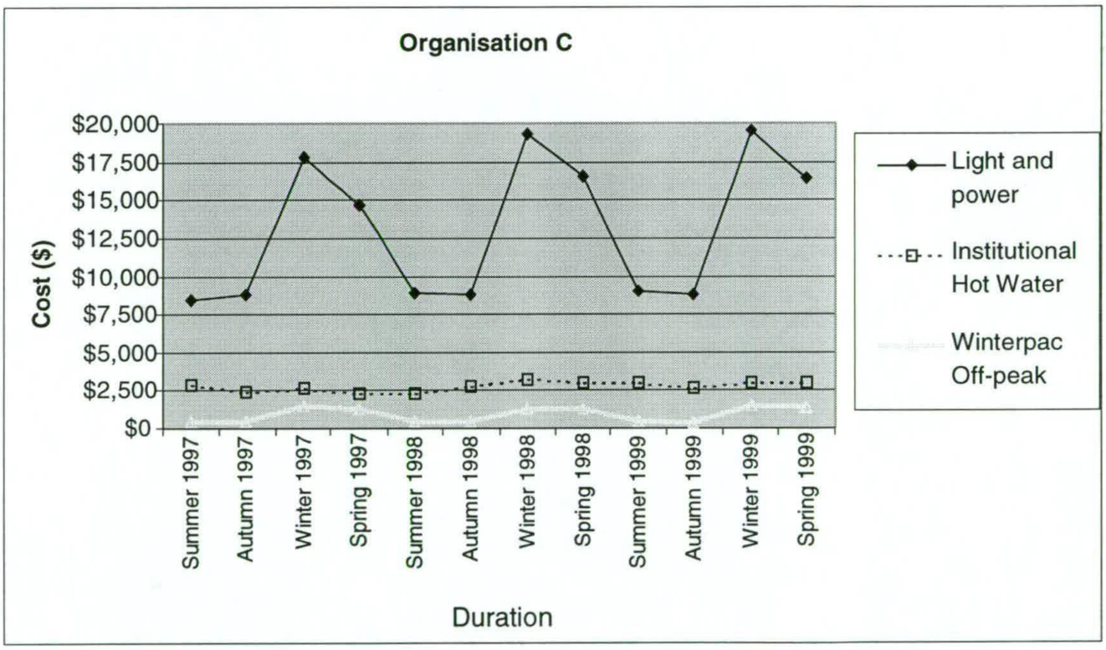
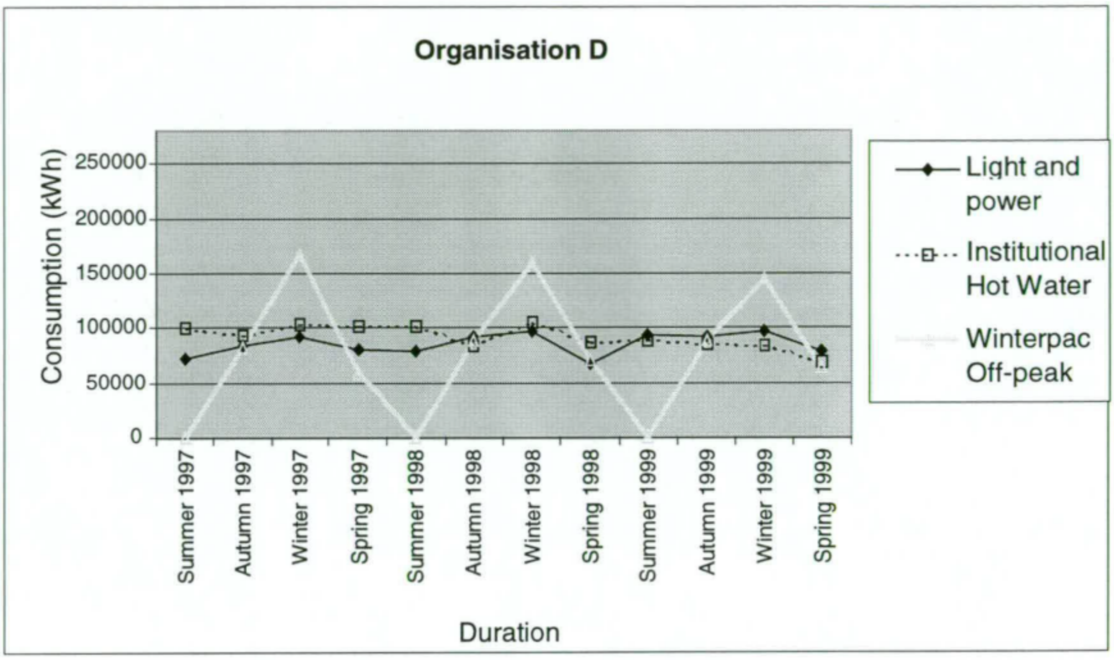


FIGURE 4.15

Periodic electricity consumption and payment for Organisation C between the years 1997 and 1999



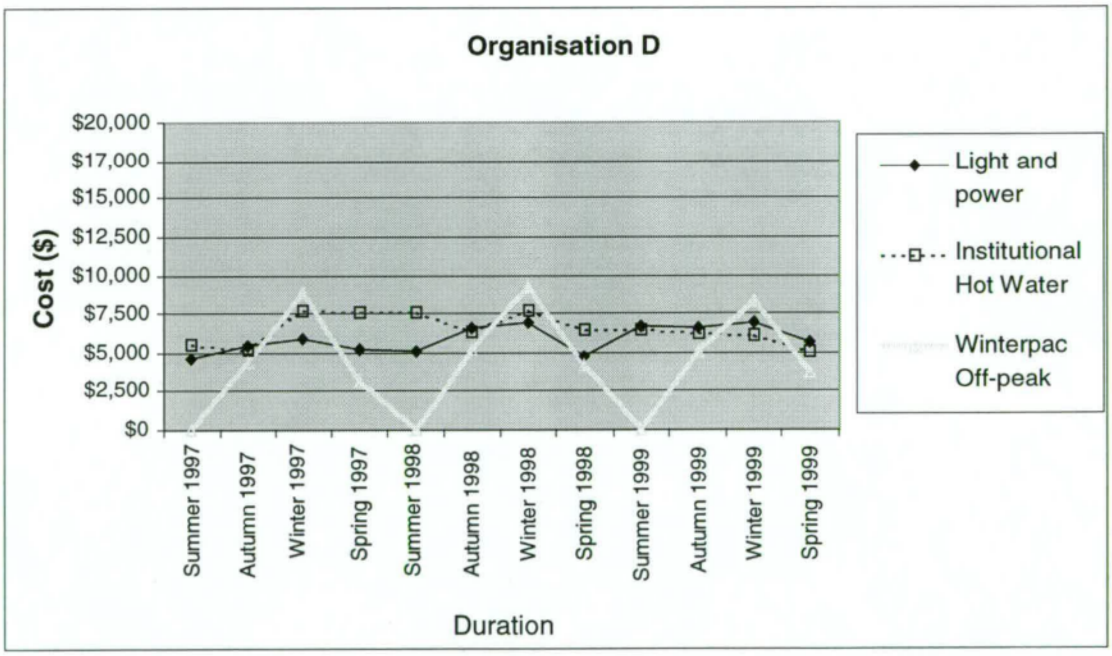


FIGURE 4.16
Periodic electricity consumption and payment for Organisation D between the years 1997 and 1999

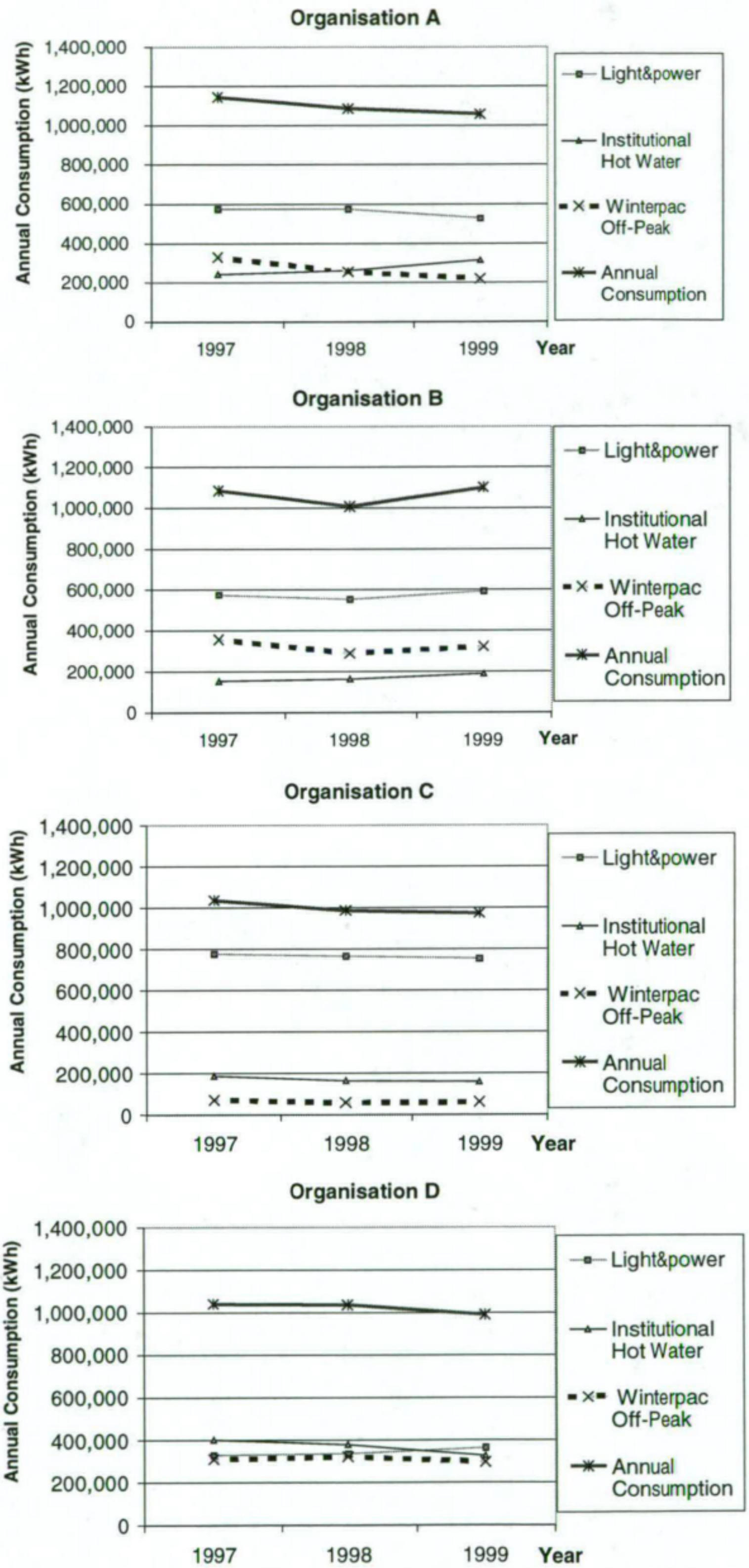


FIGURE 4.17

Annual Electricity Consumption for the four aged care organisations between the years 1997 and 1999

The trend of annual institutional hot water electricity consumption of Organisation A and B increased gradually between the years 1997 and 1999 (Figure 4.17). In contrast, the consumption dropped slightly for Organisation C and D. The trend of annual winterpac off-peak electricity consumption of Organisation A fell gradually between the years 1997 and 1999. However, the consumption was up and down for Organisation B; while the consumption for Organisation C and D remained unchanged. Consumption for light and power increased slightly between 1997 and 1999 in Organisation D, decreased slightly for C, and fluctuated for Organisation B. Consumption levels for Organisation A were similar for 1997 and 1998, but dropped slightly in 1999 (Figure 4.17).

Organisation A was the only nursing home which used fuel wood, with this being for space heating only. The annual fuel wood consumption in the years 1997, 1998, and 1999 were 21377, 21999, and 18888 kWh respectively.

The amount of gas or electricity used for cooking, hot water heating, or clothes washing and drying in an aged care organisation depends upon the number of residents in that organisation. However the amount of electricity used for space heating or lighting, or the amount of gas or fuel wood used for space heating, are more likely to be related to floor areas of that organisation. Because the numbers of residents and the floor areas of the main buildings in the four aged care organisations were not the same, consumption indices in kWh/m^2 and kWh/resident were used to compare energy performance between the four organisations (Table 4.7).

Organisation	Carbon fuels (LPG and firewood) (kWh/m^2)	Electricity (kWh/m^2)				Total energy (kWh/m^2)
		Light and power	Institutional hot water	Winterpac off-peak	Total electricity	
A	31	91	53	38	182	213
B	25	124	39	68	231	256
C	70	138	29	11	178	248
D	41	67	61	55	183	224
Organisation	**Carbon fuels (LPG and firewood) (kWh/resident)**	**Electricity (kWh/resident)**				**Total energy (kWh/ resident)**
		Light and power	Institutional hot water	Winterpac off-peak	Total electricity	
A	1943	5684	3306	2378	11368	13311
B	1190	5855	1856	3189	10900	12090
C	3555	7002	1477	547	9026	12581
D	1836	2970	2700	2430	8100	9936

TABLE 4.7

Annual carbon fuel, electricity, and total energy consumption indices (in kWh/m^2 and kWh/resident) for the four aged care organisations in 1999

The relative levels of total energy consumption of the four aged care organisations varied depending on whether they were considered in relation to floor area or numbers of residents. Organisation A had the lowest annual total energy consumption index in kWh/m^2, followed by Organisations D and C, while Organisation B had the highest (Table 4.7). In contrast, Organisation A had the highest annual total energy consumption index in kWh/resident, followed by Organisations C and B, while Organisation D had the lowest.

The relative levels of total electricity consumption of the four aged care organisations also varied depending on whether they were considered in relation to floor area or numbers of residents. Organisation C had the lowest annual total electricity consumption index in kWh/m^2, followed by Organisations A and D, while Organisation B had the highest (Table 4.7). In contrast, Organisation D had the lowest annual total electricity consumption index in kWh/resident, followed by Organisations C and B, while Organisation A had the highest.

In contrast to total energy consumption and total electricity consumption, the relative levels of electricity consumption for light and power of the four aged care organisations were similar irrespective of whether they were considered in relation to floor area or numbers of residents. Organisation C had the highest annual electricity consumption for light and power index in both kWh/m^2 and kWh/resident, followed by Organisations B and A, while Organisation D had the lowest (Table 4.7).

The relative levels of carbon fuel consumption of the four aged care organisations were also similar irrespective of whether they were considered in relation to floor area or numbers of residents. Organisation C had the highest annual carbon fuel consumption index in both kWh/m^2 and kWh/resident, while Organisation B had the lowest (Table 4.7). However, carbon fuel consumption for Organisation A per floor area was less than that for Organisation D, whereas that for Organisation A per resident was greater than that for Organisation D.

4.2.1.2 Walk-through audit

➪ Pre-audit visits

Some of the data from the pre-audit visits in each aged care organisation were previously presented in section 4.1.2 Site Descriptions.

➪ Audit surveys

Photos of each aged care organisation's buildings were already shown in section 4.1.2 Site Descriptions. The building components and energy or electrical appliances used for the four aged care organisations from the audit surveys are presented below.

Organisation	Roofs*	Floors	Walls
A	❑ Flat metal roofs	❑ Newest part of buildings: floors cork over concrete floors; ❑ Other part of buildings: concrete floor with no additional insulation	❑ Brick veneer with no additional insulation
B	❑ Partly tile and partly metal deck roofs	❑ Concrete floor with no additional insulation	❑ Brick veneer with no additional insulation
C	❑ Metal deck roofs	❑ Concrete floor with no additional insulation	❑ Brick veneer with no additional insulation
D	❑ Tile deck roofs	❑ Floors cork over concrete floors	❑ Brick veneer with no additional insulation

TABLE 4.8
Lists of roof, floor and wall constructions with in the four aged care organisation.
*Additional insulation for the roofs are not shown in this table, but are presented in the audit measurements section

Wall insulation was not present in any aged care organisation while floor insulation was present in Organisations A and D (Table 4.8). Organisation A had floor insulation only in a part of the main buildings (the newest building that installed an underfloor heater). However, Organisation D had floor insulation in most parts of the main buildings since underfloor heaters were the dominant heat source for the main buildings.

Organisation	Window frames	Coverings for windows and glass walls
A	Wooden and metal frames	Long fitted or short curtain without pelmets
B	Metal and wooden frames	Long fitted or short curtain without pelmets and inner roller shutters
C	Metal frames	Long fitted curtain with pelmet box and inner roller shutter. Some also had external metal roller shutter.
D	Wooden frames	Venetian blinds with pelmet box and light weight curtains on rod

TABLE 4.9

Window frames and coverings for windows and glass walls in the four organisations

There were some differences between different organisations in the materials used for window frames (Table 4.9). Window frames in Organisation D were wooden while Organisation C had metal frames. Organisation A and B had wooden frame windows for old buildings while metal frames were used in the new buildings (Table 4.9).

FIGURE 4.18

Photographs of skylights (with and without protection) along corridors in aged care organisations

Both vented and unvented skylights, glass walls, and big windows were commonly found in all organisations along corridors, toilets and bathrooms, dining rooms, recreation rooms, communal rooms, and residential rooms. All the glass walls, windows and skylights used single glazing. Most windows and glass walls had some additional covering to reduce heat transfer, such as curtains, roller shutters, or venetian blinds (Table 4.9). However, most skylights had no additional protection, except a few skylights that had venetian blinds (Figure 4.18)

Unprotected skylights can be a major source of temperature control problems in buildings, by allowing heat losses in winter and heat gains in summer. This can dramatically increase energy consumption for both heating and cooling in buildings. Even though cooling cost is not a major issue for these organisations, because none of them used air conditioning for cooling, the heat gain from skylights can cause an overheating problem. Such a problem used to occur in Organisation C, where overheating was common in summer because of too many skylights in the buildings. The problem was solved five years ago by covering some skylights with corrugated roofing iron and sealing the underside with plaster board. Now there are only some skylights left along the corridors, bathrooms, and toilet areas.

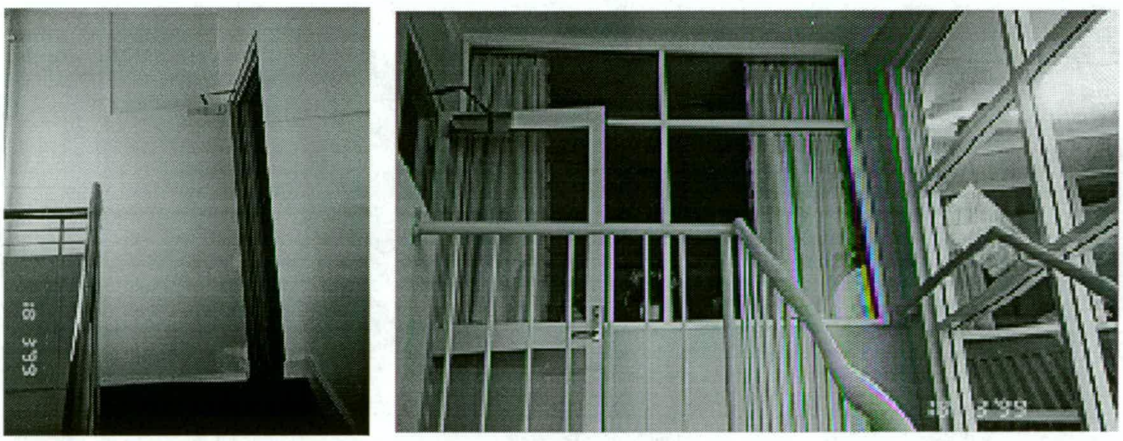


FIGURE 4.19
Photographs of automatic door closer at stairwells in aged care organisations

In all organisations, external doors had automatic door closers and weather strips to seal gaps between the doors and their frames. Internal doors to limit the escape of heated air were placed in a number of sections of the main buildings. These were typically positioned at the stairwells (Figure 4.19), corridors, and at the nursing resident section as security doors.

A variety of artificial light fittings and equipment were used in different areas of aged care organisations (Table 4.10). All organisations combined artificial lighting with natural light from skylights, windows and glass walls. Two types of lamp, incandescent globes and fluorescent tubes, were used in all organisations. In addition, Organisations A and B both used compact fluorescent lamps (CFL). Organisation A also used high pressure sodium lamps, while Organisation B also used low pressure halogen lamps.

Areas of buildings	Organisation A	Organisation B	Organisation C	Organisation D
Corridors	60W incandescent or 20W CFL or 36W fluorescent tube for down light	28W 2D CFL or 75W incandescent or 36W fluorescent tube for down light and 26W CFL for wall washer	75W incandescent or 36W fluorescent tube for down light and 40W incandescent for wall washer	36W fluorescent tube for down light
Residential rooms	60W incandescent or 20W CFL or 36W fluorescent tube	28W 2D CFL or 60 W incandescent or 36W fluorescent tube	60W incandescent	60W incandescent
Communal rooms	36W fluorescent tube	28W 2D CFL or 75 W incandescent or 36W fluorescent tube	36W fluorescent tube and 60W incandescent	36W fluorescent tube
Kitchens	36W fluorescent tube	36W fluorescent tube	36W fluorescent tube	36W fluorescent tube
Laundries	36W fluorescent tube	36W fluorescent tube	36W fluorescent tube	36W fluorescent tube
Toilets	100W incandescent	100W incandescent or 28W 2D CFL	100W incandescent	60W incandescent
Bathrooms and showers	60W incandescent or 18W fluorescent tube	28W 2D CFL or 75W incandescent	100W incandescent	60W incandescent
Offices	15W CFL for task light and 36W fluorescent tube for general light	20W low pressure halogen for task light; 36W fluorescent tube with aluminium reflector and 26W CFL for general light	36W fluorescent tube	36W fluorescent tube
Dinning rooms	36W fluorescent tube	20W CFL and 36W fluorescent tube	36W fluorescent tube	36W fluorescent tube
Outdoor	60W incandescent, 125W high pressure sodium lamp, 120W spot light, 18W fluorescent tube, and 9W CFL	150W incandescent, and 20W low pressure halogen lamp	100W incandescent and 36W fluorescent tube	150W incandescent and 36W fluorescent tube

TABLE 4.10

Artificial light systems used in different areas of the four organisations

Similar types of office equipment were used in all aged care organisations. These included fax machines, desktop computers, photocopying machines, and printers. Cooling systems in the various organisations were also similar, with all involving electric fans. In contrast, many different types of heaters were used in the various organisations. However, the majority of heaters in all organisations were powered by electricity, even though there were a few gas and wood heaters in some organisations.

Heaters used electricity on both winterpac off-peak and normal light and power tariffs in all organisations. The tariffs for winterpac off-peak were always lower than light and power tariffs, in spite of occasional price changes. For instance, the latest tariffs for the year 2000 for winterpac off-peak tariff (Tariff 61) by Aurora Energy is 5.951 cents per kWh (for all kWh) while for nursing homes light and power (Tariff 34) are 12.391, 9.634, and 7.492 cents per kWh (for first 500 kWh, next 500 kWh, and remainder) (http://www.auroraenergy.com.au/brochures/business_rates_2000/ index.htm#general_commercial: 2/04/2000).

The heater types used varied between different organisations. All organisations used numerous space heaters to heat the entire area of their main buildings. However, Organisation D used central heating systems as their main heat source for these areas, reducing their need for individual space heaters. Organisations A and B also used a central heating system in one part of their main buildings. Infra-red heat lamp radiant heaters were commonly installed on the ceilings to heat toilet and bathroom areas in all organisations. Types of heaters used in other areas in each organisation are listed below, and photographs of some heaters used in the four organisations are shown in Figure 4.20.

- Organisation A: Two gas heaters and two wood heaters were used in communal rooms for hostel residents. Ceiling radiant heaters were used in communal resting areas for nursing residents. Oil-fill column and off-peak storage convection heaters were used in all residential rooms, dining rooms, corridors and office areas. An off-peak storage underfloor heater was also used in the newest wing of the main buildings.

- Organisation B: An off-peak storage underfloor heater with individual room thermostats was operated in an area for nursing residents in the main buildings. However, other areas for hostel and nursing residential bedrooms were heated by a variety of space heaters, such as wall mounted radiant strips, oil-fill column, skirting convection, or low wall convection heaters. A heat pump was operated in

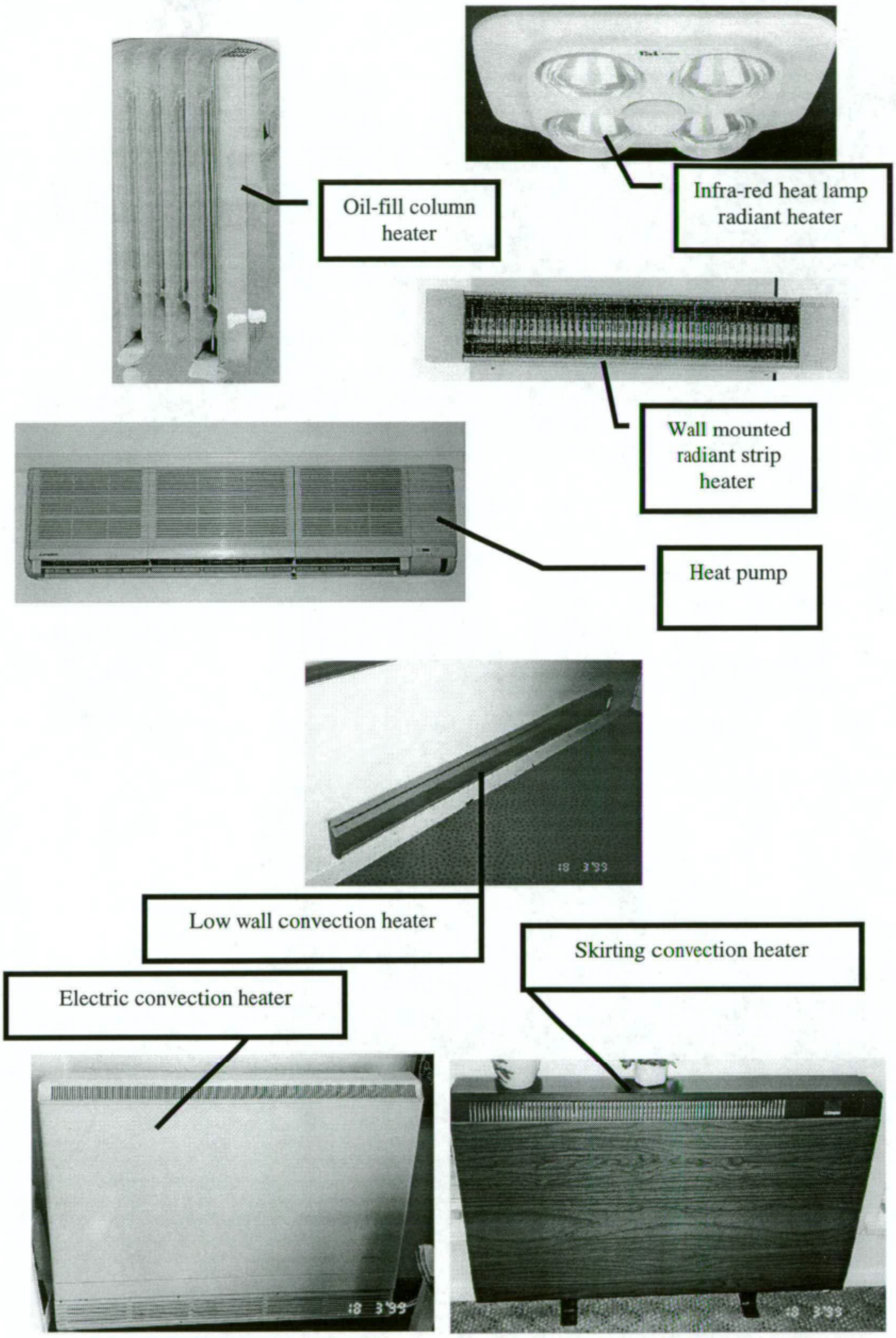


FIGURE 4.20

Photographs of common heaters operated in the four organisations one dining room that had a high ceiling (6 metres), while other dining rooms used off-peak storage convection heaters. Electric convection and off-peak storage convection heaters were used to heat offices and corridors. Communal rooms were heated by electric convection heaters while recreation rooms were heated by two gas heaters.

- Organisation C: Electric convection heaters (low wall and skirting) were used in residential rooms, communal rooms, offices and corridors, while off-peak storage column heaters were used in dining rooms.

- Organisation D: Off-peak storage underfloor heaters were operated in most areas of the main buildings, including residential rooms, communal rooms, corridors, and offices. This organisation also used electric convectional and off-peak storage column heaters for additional heat in residential rooms.

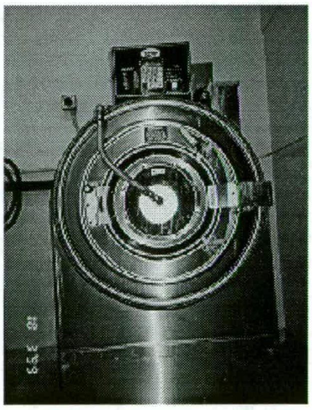


FIGURE 4.21

Photographs of aged care commercial size washing machine and gas tumble drier

Laundry appliances such as washing machines and tumble driers were found in both household and commercial sizes (Figure 4.21). There were normally two commercial size washing machines, with maximum load of 16 or 23 kg, in each organisation. However, the number of commercial size gas tumble driers differed slightly between organisations. Organisation A had two 31 kW commercial size gas tumble driers. Organisation B had one 31 kW and one 48 kW commercial size gas tumble driers. Organisation C had five commercial size gas tumble driers, comprising one 48 kW;

two 41 kW, and two 26 kW. Organisation D had three 31 kW commercial size gas tumble driers.

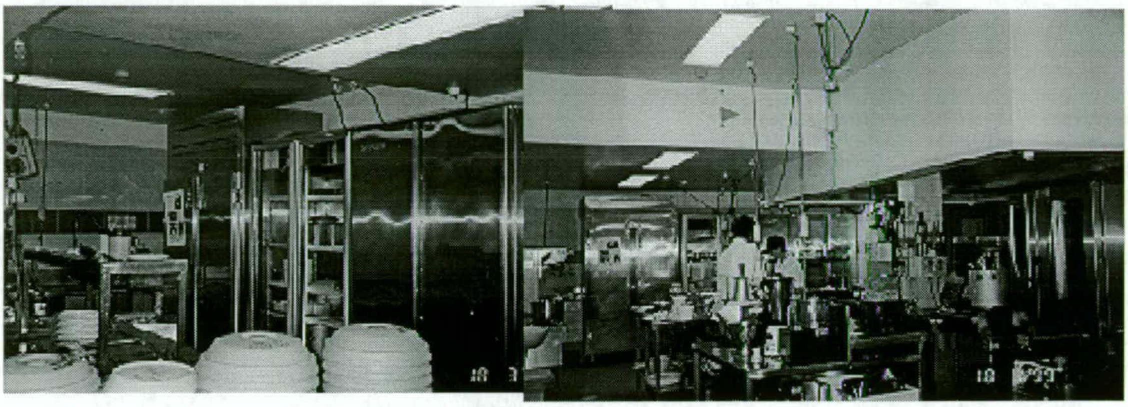
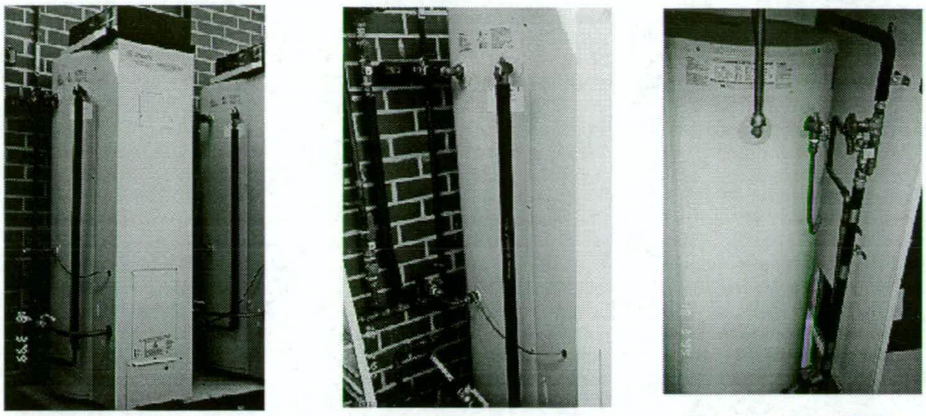


FIGURE 4.22
Photographs of aged care kitchens

Kitchen appliances used in all organisations were similar in size and number (Figure 4.22). Gas was used for cooking in all organisations, with gas grillers, gas stoves, and commercial size gas ovens being used. Electricity was used to power commercial size refrigerators and freezers in all organisations.

Hot water used in kitchen and laundry for the organisations was heated by gas and/or electricity (Figure 4.23). Organisation A had a 280 litre gas hot water cylinder for supplying the kitchen, while the laundry hot water was supplied by a 250 litre mains pressure electric hot water cylinder. Organisation B had two gas hot water cylinders, of 265 and 280 litres, for their kitchen and laundry. Organisation D also had two gas hot water cylinders; both 265 litres for their kitchen and laundry. Organisation C had two 265 litre gas fuelled cylinders for supplying the laundry, and also a 250 litre mains pressure electric hot water cylinder for the kitchen.



Gas hot water system

Rubber insulation for hot water pipes

Electric hot water system

FIGURE 4.23
Gas and electric hot water systems and pipe rubber insulation in aged care organisations

In contrast, the hot water used in residential areas by residents and staff of all organisations was supplied exclusively from electric hot water cylinders. This hot water was used for residential showers (25%), residential baths (25%), cleaning and sanitary purposes (25%), residential and staff hand basins (9%), and other purposes 16%). The percentages of hot water used in each area were calculated from hot water consumption observations made by a maintenance officer between 7 am and 11 am in one aged care organisation. These hot water consumption observations were: 363 litres for residential showers, 352 litres for residential baths, 354 litres for cleaning and sanitary purposes, 131 litres for residential and staff hand basins, and 232 litres for other purposes. These electric hot water cylinders encompassed mains pressure or both low and mains pressure systems. In Organisations A, B and C, each cylinder was connected to pipes servicing the nearby areas (direct to points), with the cylinders distributed throughout the buildings. Hot water pipes in all organisations, except Organisation C, had a short section of rubber insulation for approximately the first metre from the hot water cylinder (Figure 4.23). However, only Organisation D had insulation for hot water pipes in the walls. Organisation A had 10 mains pressure hot water cylinders; four of 250 and six of 315 litres. Organisation B had two low pressure hot water cylinders and nine mains pressure hot water cylinders; one of 160, two of 315, and six of 250 litres. Organisation C had seven low pressure hot water cylinders and eight mains pressure cylinders. Organisation D had 16 mains pressure hot water cylinders; twelve of 315 litres, four of 250 litres, and two of 265 litres. However, the electric hot water system for Organisation D was different to others. The hot water cylinders were grouped together in clusters (Table 4.11), rather than being distributed individually around the building. Hence, the average distance between cylinders and hot water taps was greater in Organisation D than in the others. Hot water from each cluster of cylinders was circulated constantly through hot water pipes under the roof with the aid of an electric pump. To reduce heat loss from the system, hot water pipes under the roof were covered with rubber insulation. In all organisations, there was one shower provided for 2-3 residents and one bath provided for around 20 residents. However, none of these organisations used low flow shower heads to restrict their hot water usage.

Group	Number of cylinder × capacity (litres)	System type
A	3 × 315	Electric mains pressure with pumped circulating hot water system
B	3 × 315	Electric mains pressure with pumped circulating hot water system
C	6 × 315	Electric mains pressure with pumped circulating hot water system
D	2 × 250	Electric mains pressure with pumped circulating hot water system
E	2 × 250	Electric mains pressure with pumped circulating hot water system
Non grouped	2 × 265	Gas mains pressure, direct to points

TABLE 4.11

System types and number and capacities of hot water cylinders in Organisation D

➪ Audit measurements

1) Building dimensions and orientations

Dimensions and orientations of buildings in each aged care organisation were earlier displayed in section 4.1.2 Site Descriptions.

2) Ceiling heights

Organisation	Ceiling heights (metres)		
	average	minimum	maximum
A	2.83	2.5	5.0
B	2.99	2.5	6.0
C	3.08	2.2	6.0
D	2.57	2.4	3.0

TABLE 4.12

Averages and ranges of ceiling heights in the four aged care organisations

Average ceiling heights were lower in Organisation D than in the other organisations because of the absence of very high ceilings there (Table 4.12). In the other three organisations, high ceilings were commonly found in areas of skylights and sometimes in dining and recreation rooms.

3) Insulation thickness above ceilings

Insulation is essential to reduce heating and cooling loads by making the building fabric more resistant to heat transfer. The level of thermal resistance (R-value) is a measure of the ability of the insulation material to resist the flow of heat (Energy Victoria 1997c). The higher the R-value, the greater the resistance to heat flow. In general, the more severe the climate, the higher the R-value required for roofs and ceilings. In Hobart, the level of thermal resistance to be added to an uninsulated roof/ceiling space recommended by the Standards Association of Australia (1993: 29) is R3.

Organisation	Additional thermal resistance for roof/ceiling space	Insulation materials for roof/ceiling space for the main buildings
A	R1.2 - R2.4	□ Fibreglass batts 55mm (R1.2) and loose fill cellulose fibre 50mm (R1.2); or
		□ Loose fill cellulose fibre 50 mm (R1.2)
B	R0 - R1.63	□ Fibreglass batts 60mm (R1.4) and reflective insulation (R0.23); or
		□ Fibreglass batts 60mm (R1.4); or
		□ None
C	R1.73	□ Fibreglass batts 70mm (R1.5) and reflective insulation (R0.23)
D	R2.23	□ Rockwool batts 75mm (R2.0) and reflective insulation (R0.23)

TABLE 4.13

Additional thermal resistance values and materials for roof/ceiling in the four aged care organisations

Two of the aged care organisations had a variety of additional thermal resistance materials for their roof/ceilings space in different parts of the main buildings, while the other two organisations had uniform thermal resistance materials throughout the main buildings (Table 4.13).

Overall from Table 4.13, every aged care organisation had an additional thermal resistance for all parts or at least some parts of their roof/ceilings. Nevertheless, none of the four organisations had an additional thermal resistance for roof/ceiling space which met the Standards Association of Australia's recommendation.

4) Light illumination

The light intensities for the four organisations determined from the lux meter were between 80 and 9500 lux. This was generally much greater than the recommendations for Australia, Denmark, and the United Kingdom (Table 4.14), and those recorded in Victoria and Thailand (Table 4.15). However, it was not possible to tell whether the artificial lighting was in excess of requirements. This is because, as the lux meter was used in the surveys during daytime, it was not possible to measure the actual light intensity from the artificial lighting source. Light intensity read from the lux meter included both light intensity from natural light (sunlight) as well as artificial lights. Most of the areas in all aged care organisations received natural light from windows, glass walls and doors, and/or skylights.

Building types and areas	Australia AS1680.2-1990	Denmark DS700	United Kingdom 1994 IES/CIBSE
Office-general	160	200-500	500
Office-reading task	320	500	300
Hospital-common areas	240	200	-
Hospital-patient rooms	-	50-200	30-50

TABLE 4.14

Comparison of recommended lighting levels in Australia, Denmark, and United Kingdom (adapted from Mills and Borg 1998: 6-7)

Areas in buildings	Light intensity[1] (lux)	Light intensity[2] (lux)
Bathrooms and toilets	-	100
Corridors, walkways, stairs	40	150
Bedrooms	-	50
Bed-lights	-	200
Kitchens	240	300
Recreation and reading rooms	240-400	500

TABLE 4.15

Typical levels of illumination in common areas of accommodation buildings ([1]Energy Victoria 1994, [2]Banchongchit 1995)

5) Air leakage around vented skylights and ventilation loss calculations

It was very difficult to measure and calculate airflows passing through vented skylights using an airflow anemometer (wind velocity TA 3000). As the draughts were influenced by external wind speeds, the rate of air leakage fluctuated greatly while measurements were being taken. Moreover, differences in external wind speeds while investigating different skylights confounded the results. Hence, it was not possible to make direct comparisons between skylights of the rates of air leakage. As a consequence, the recorded airflows during 5 minute periods can only be considered as very rough estimations.

Average wind speeds through vented skylights in this study ranged between 0.5 and 2 m/s, and the most common size of vented skylights in the four organisations was 1m × 1m, with a 5 cm permanent gap around the perimeter.

An example of ventilation loss calculations were given below by assuming that the average airflow of an organisation is 1 m/s, and the size of vented skylight is 1m × 1m with a 5 cm permanent gap. Ventilation loss from this skylight per hour is calculated below:

$$1 \text{ m/s} \times (4\text{m} \times 0.05\text{m}) \times 3600 \text{ s/h} = 720 \text{ m}^3\text{/h}$$

Assume an aged care organisation has an average ceiling height of 2.8 m, and floor areas of the main building of 5400 m^2. If this organisation has 20 vented skylights in the main buildings, the air changes per hour will be:

$$(720 \text{ m}^3\text{/h} \times 20 \text{ skylights}) \div (5400 \text{ m}^2 \times 2.8 \text{ m}) = 0.95 \text{ air changes per hour}$$

Hence, on average, almost the entire air volume of the building passes through the vented skylights every hour. This is sufficient to meet the overall ventilation rates, of between 0.5 and 1 air change per hour (ACH), recommended for residential accommodation (DOE 1997b). However, there are many other avenues through which ventilation can occur, including bathroom and kitchen vents, wall vents, cracks around doors or windows, and open doors and windows. This additional ventilation can be quite substantial, as Todd (1994c) noted that well insulated buildings have half an air change per hour while draughty buildings have two air changes per hour. Hence, the overall ventilation rate is likely to be more than adequate in this building.

For one cubic metre of warm air that is lost from a heated building, a cubic metre of cold air from outside will enter. Hence, superfluous ventilation will increase the demand for heating energy unnecessarily, and energy costs may be reduced by sealing some of the vented skylights.

6) Measurements of air temperatures

The two nursing residential rooms in Organisation A where air temperature measurements were taken were called 'A nursing 1' and 'A nursing 2' while the two hostel residential rooms studied in this organisation were called 'A hostel 1' and 'A hostel 2'. A parallel room identification system was used for Organisation B.

Measurements in Organisation C were restricted to one nursing residential room, called 'C nursing'. In Organisation D measurements were conducted in a nursing residential room called 'D nursing' and in a hostel residential room called 'D hostel'.

The indoor air temperature control of a nursing residential room in Organisation A (A nursing 2) was by far the best of any of the rooms investigated (Figure 4.25). This was evident through the absence of changes in internal temperatures with external temperatures, and the high y-intercept of the regression line (Table 4.16). The other room for nursing residents in Organisation A (A nursing 1), one of the rooms providing hostel accommodation in Organisation A (A hostel 1), and the rooms for nursing residents in Organisations C and D (C nursing and D nursing), also exhibited minor decreases in internal temperatures with external temperatures, and generally high y-intercepts for the regression lines (Table 4.16 and Figures 4.24, 4.26, 4.32 and 4.33). However, these four rooms differed in their levels of temperature control, with that for D nursing being much greater than for the others. A hostel 1 had lower internal temperatures than the other three rooms, reducing the temperature gradient between the internal and external environments. Hence, the insulative properties of A hostel 1 were probably not quite as good as the other three rooms.

Residential rooms	Slope of lines	Y-intercepts	R^2
A nursing 1	0.1190	18.082	0.0536
A nursing 2	-0.0085	19.801	0.0009
A hostel 1	0.1576	16.467	0.1169
A hostel 2	0.2071	14.566	0.1248
B nursing 1	0.2448	13.631	0.1807
B nursing 2	0.4242	12.128	0.3763
B hostel 1	0.2729	18.334	0.3214
B hostel 2	0.2299	18.832	0.1080
C nursing	0.1511	18.388	0.1711
D nursing	0.1415	18.712	0.5395
D hostel	0.2274	18.006	0.2928

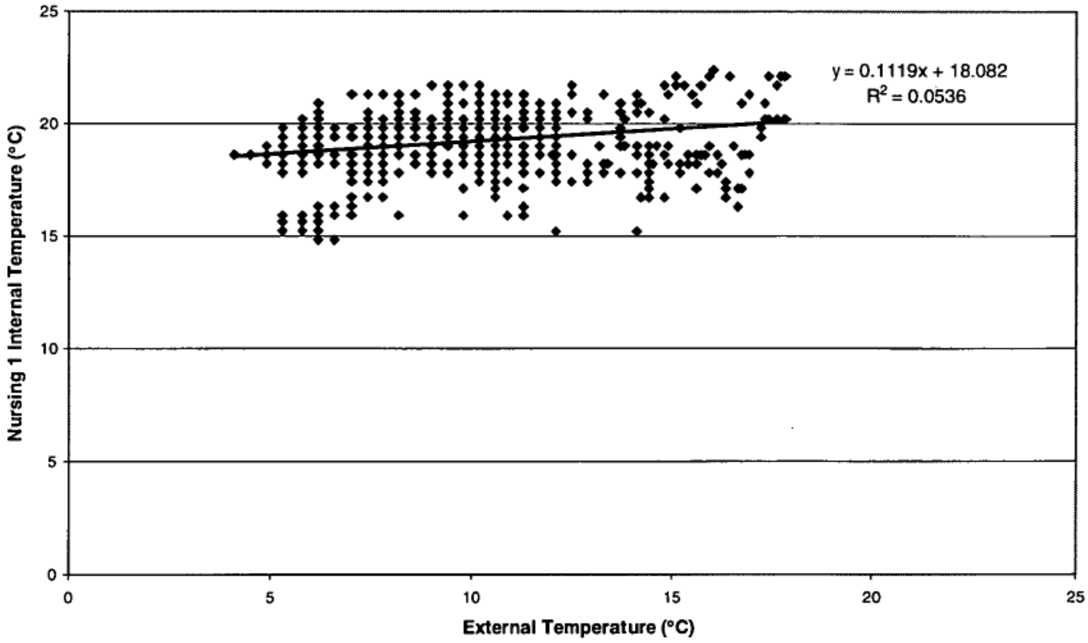
TABLE 4.16

Summary of relationships between internal and external temperatures of residential rooms in the four aged care organisations (Figure 4.24 to 4.34)

The weakest temperature control was exhibited by a nursing residential room in Organisation B (B nursing 2) (Figure 4.29). This was apparent from the steep decrease in internal temperatures with external temperatures, and the low y-intercept of the regression line (Table 4.16). The remaining rooms exhibited moderate relationships between internal and external temperatures (Table 4.16 and Figures

4.27, 4.28, 4.30, 4.31 and 4.34). However these differed in their internal temperatures, with these being much lower in A hostel 2 and B nursing 1 than in the other rooms. Hence, the insulative properties of A hostel 2 and B nursing 1 were probably not quite as good as the other three rooms.

In addition to the levels of insulation in the rooms, the type and size of heaters used, along with the temperature setting for the thermostats, also play major roles in affecting room temperatures. Floor heaters and electric convection heaters were used in the following rooms: A nursing 1; A nursing 2; D nursing; and D hostel. Oil fill column and electric convection heaters were used in rooms A hostel 1, A hostel 2, B hostel 1, B hostel 2, and C nursing. The thermostat for the heaters in rooms A nursing1, A nursing 2, and D nursing were set at 18°C by the nursing home staff, resulting in internal temperatures remaining fairly constant (Figures 4.24, 4.25, and 4.33). However, the residents in the rooms A hostel 1, A hostel 2, B hostel 1, B hostel 2, C nursing, and D hostel could adjust the temperature in their thermostat to their own comfort level. As a result, internal temperatures were highly variable in some of these rooms (Figures 4.26, 4.27, and 4.31). Radiant heaters were used in rooms B nursing 1 and B nursing 2. This explained why B nursing 1 and B nursing 2 had lower Y-intercept values than the other rooms (Table 4.16).



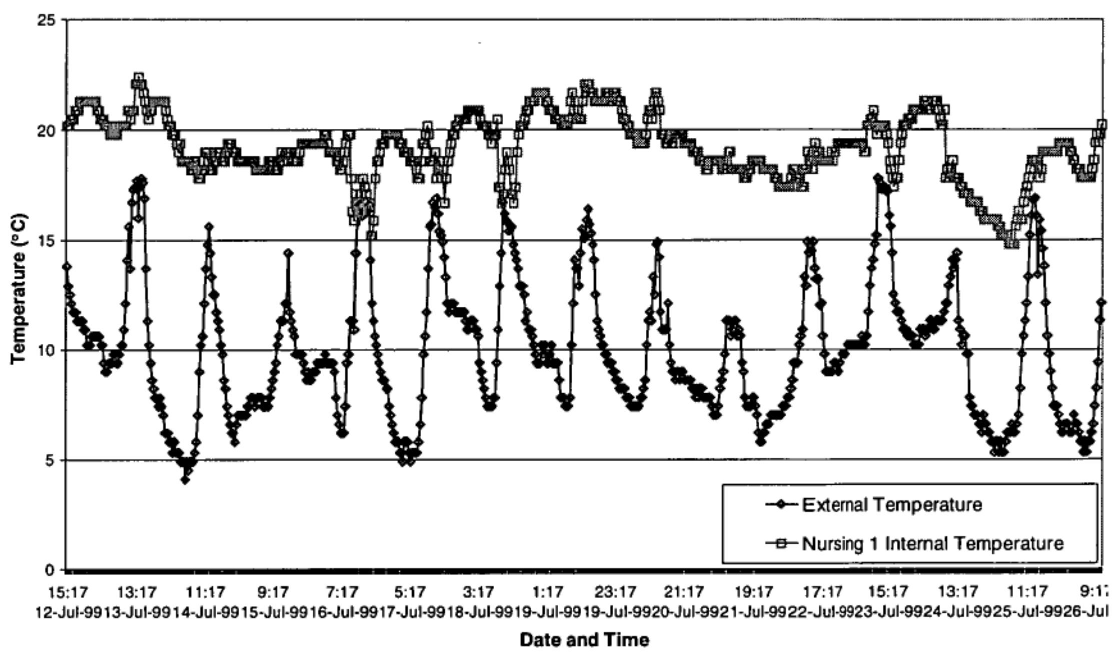


FIGURE 4.24
Temperature graph for nursing 1 residential room in Organisation A

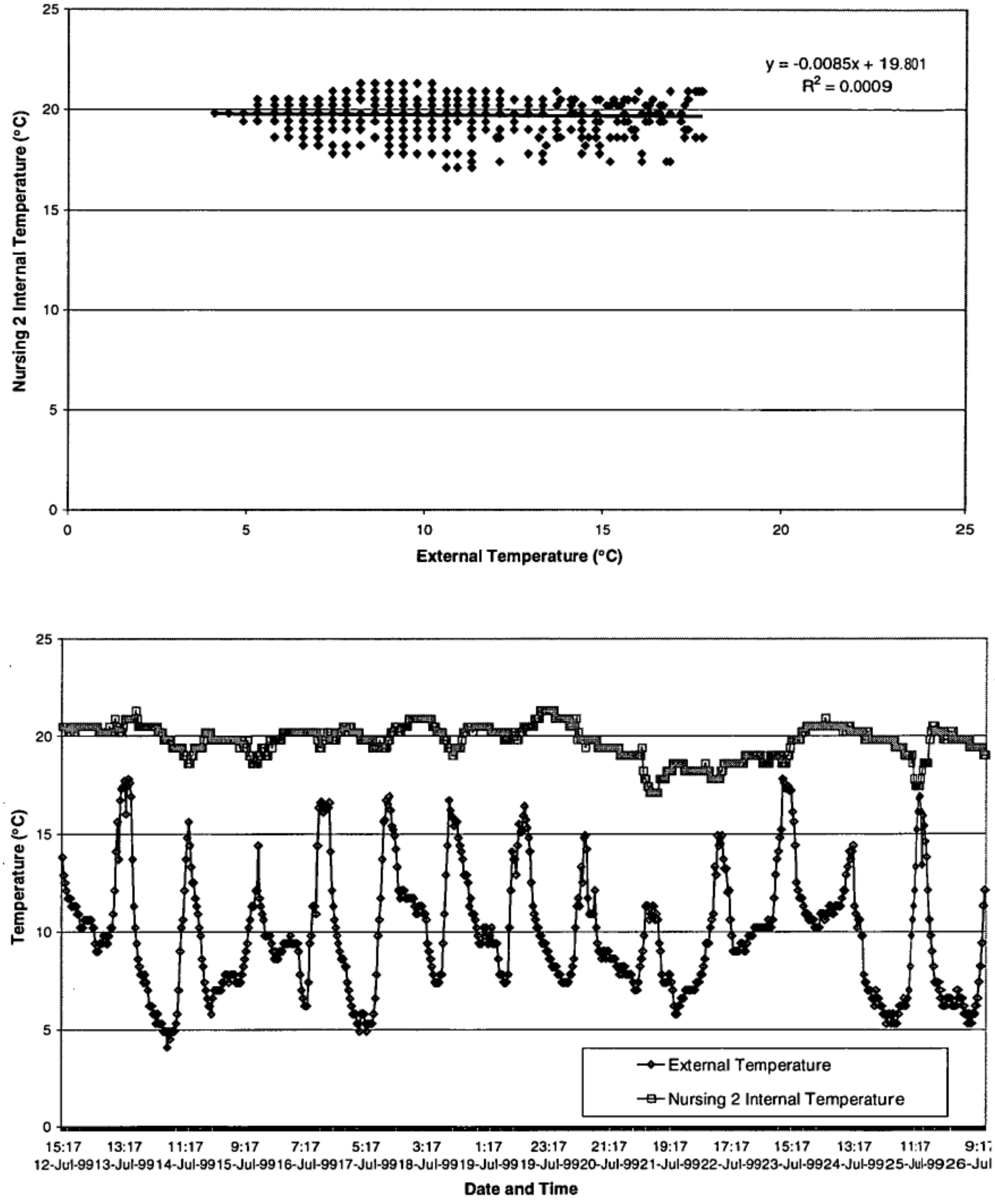
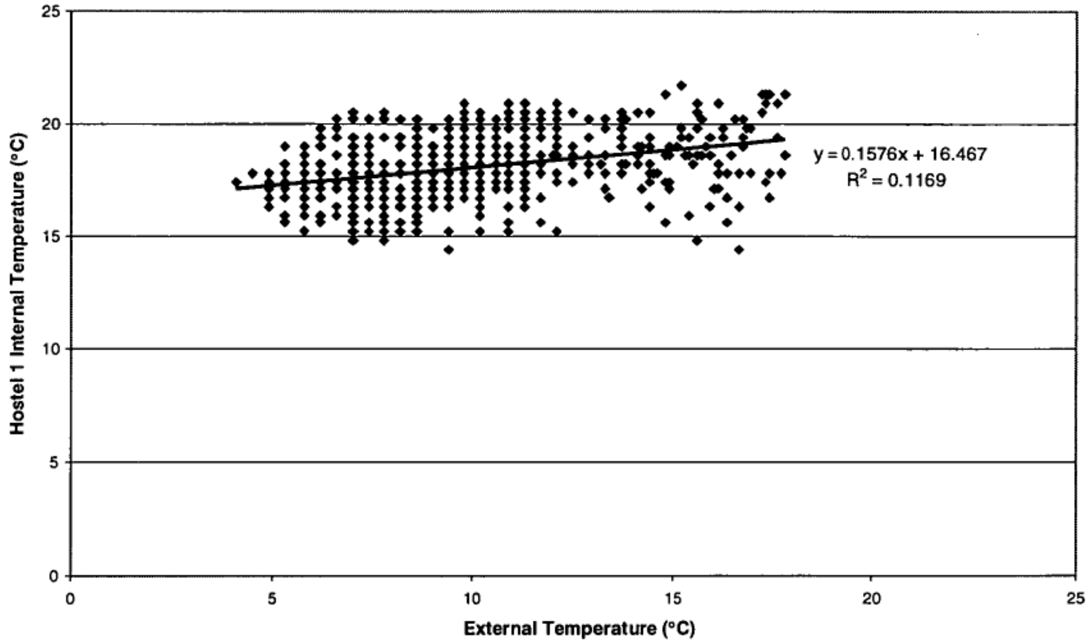


FIGURE 4.25
Temperature graph for nursing 2 residential room in Organisation A



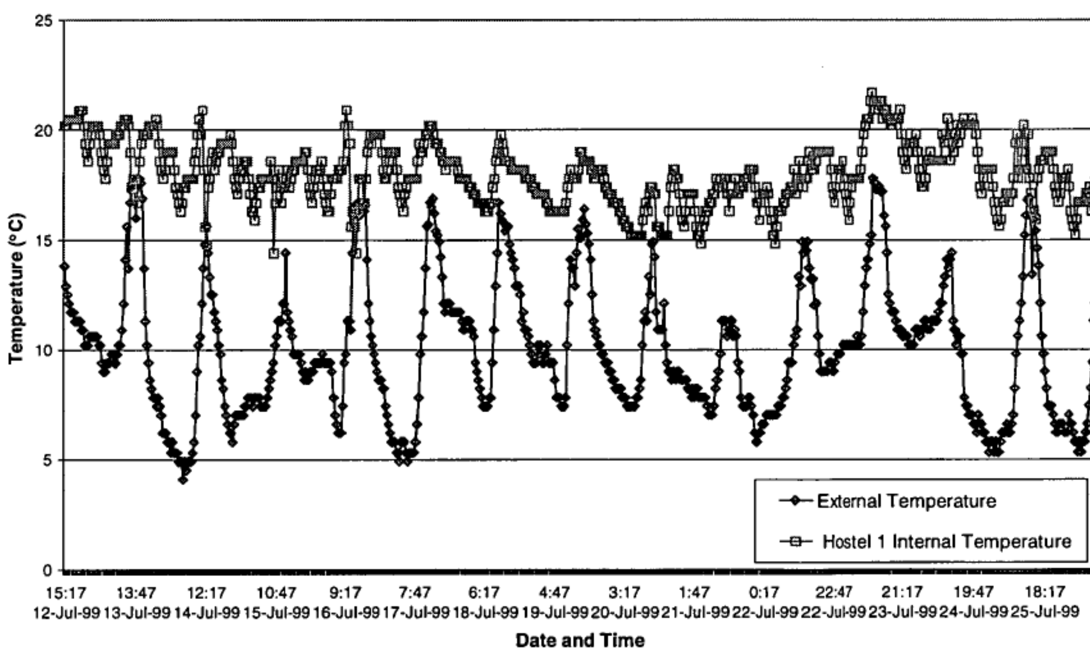


FIGURE 4.26

Temperature graph for hostel 1 residential room in Organisation A

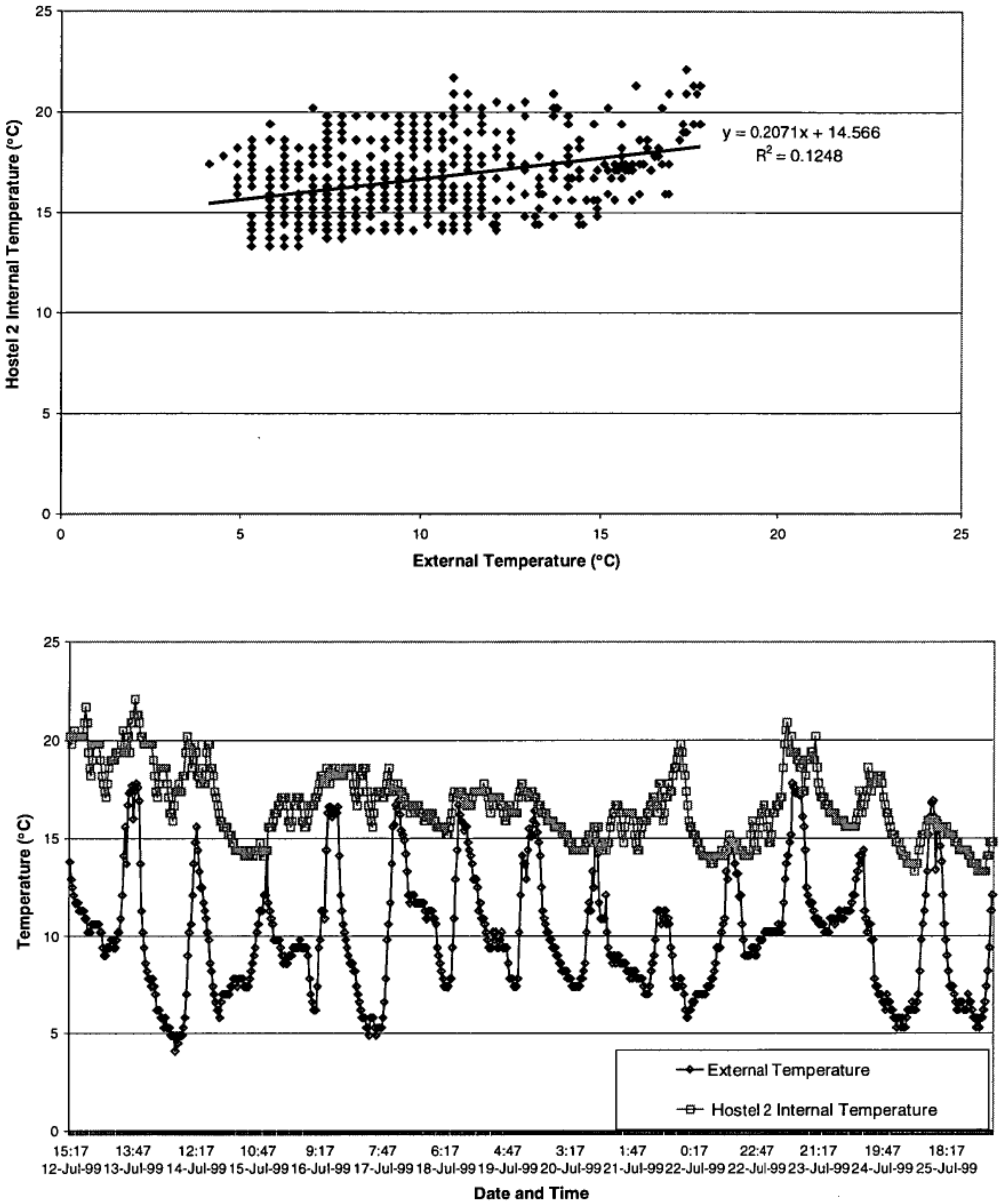
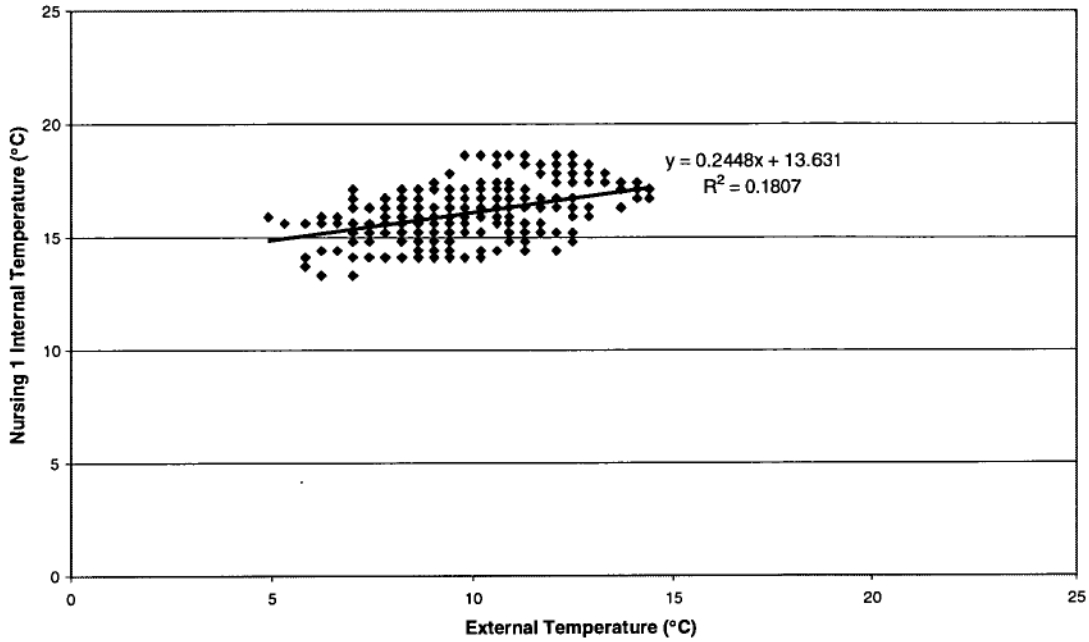


FIGURE 4.27
Temperature graph for hostel 2 residential room in Organisation A



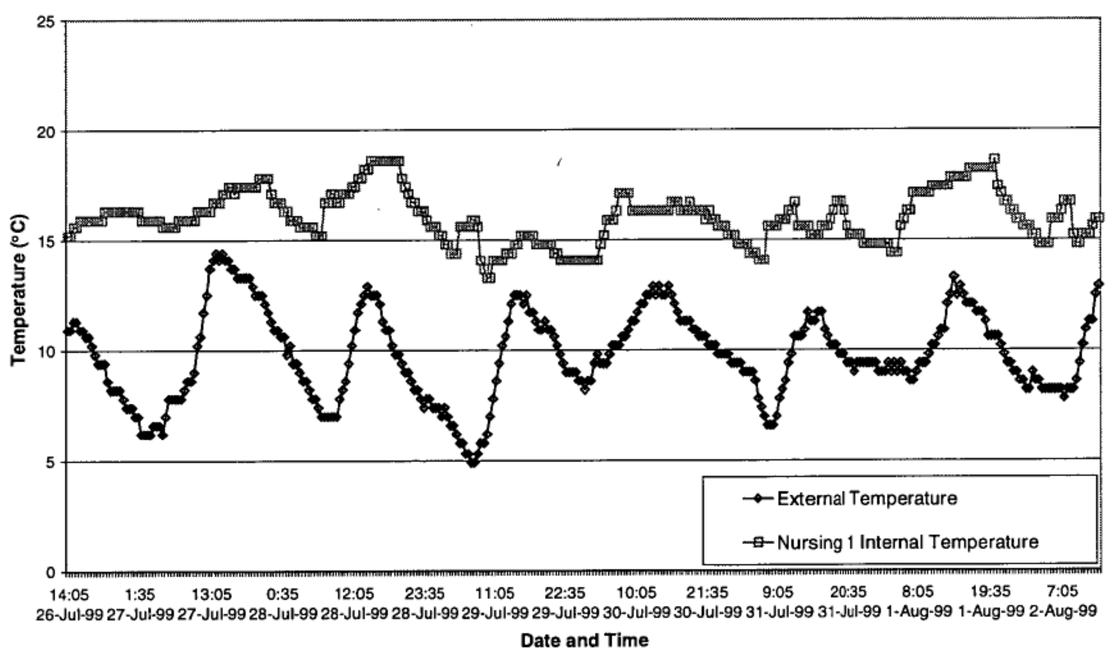
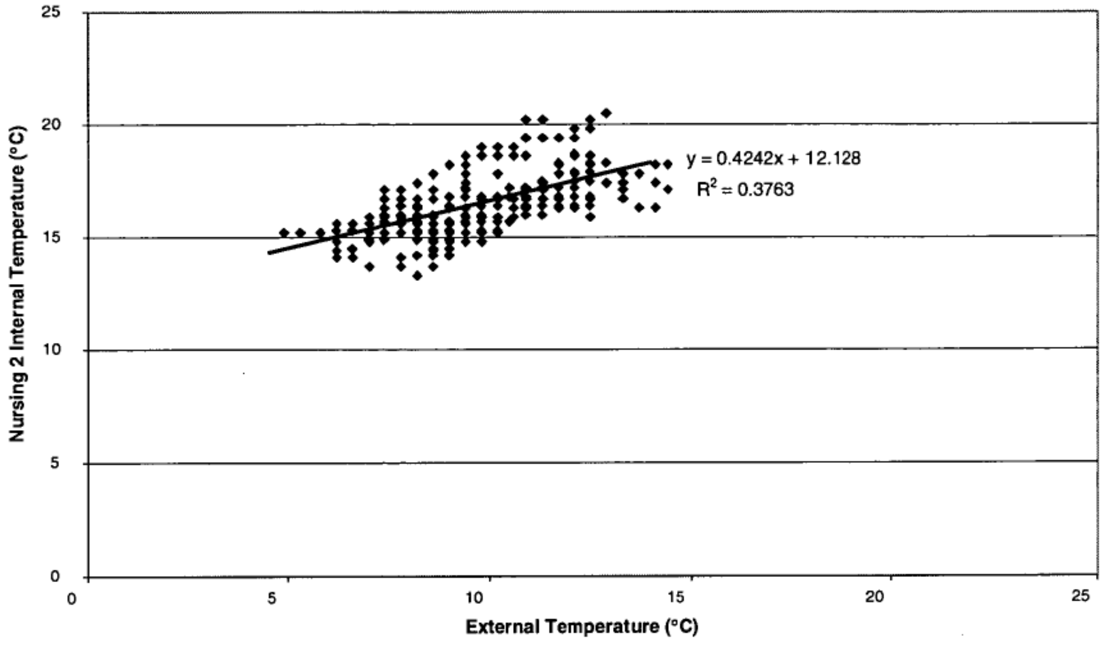


FIGURE 4.28
Temperature graph for nursing 1 residential room in Organisation B



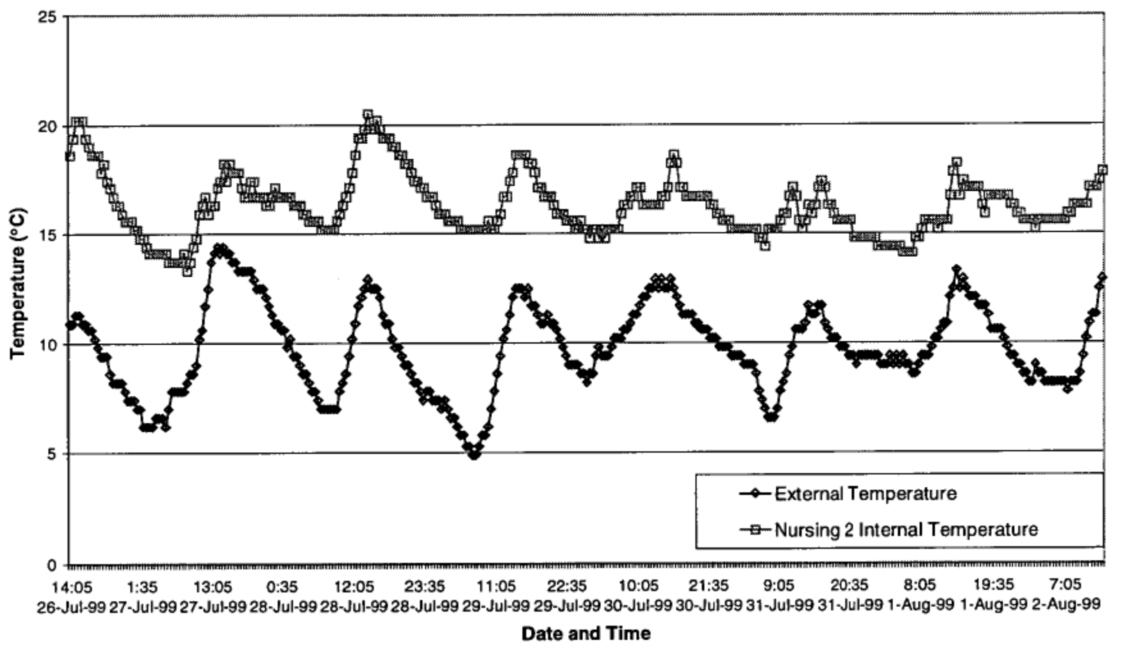


FIGURE 4.29

Temperature graph for nursing 2 residential room in Organisation B

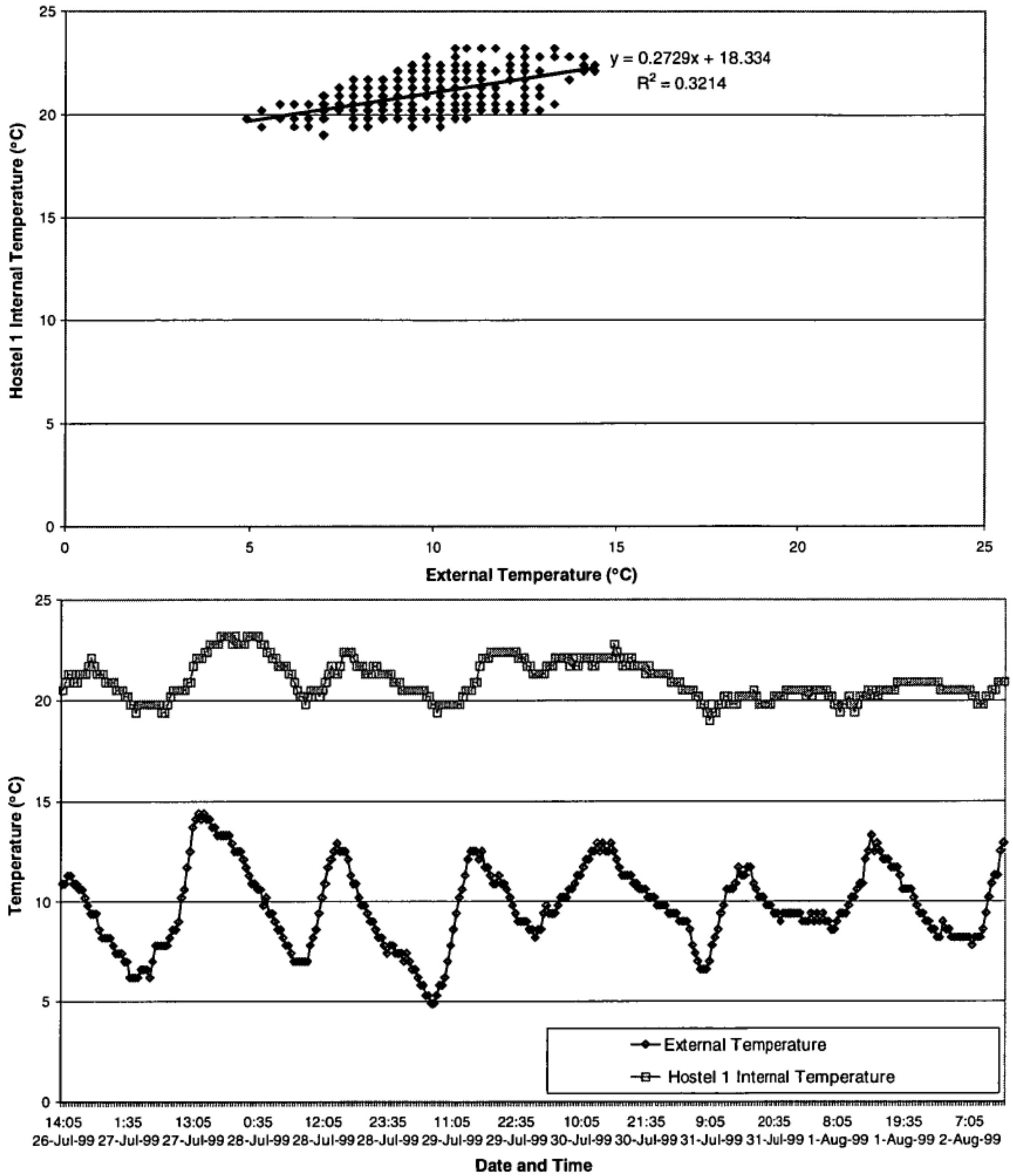


FIGURE 4.30

Temperature graph for hostel 1 residential room in Organisation B

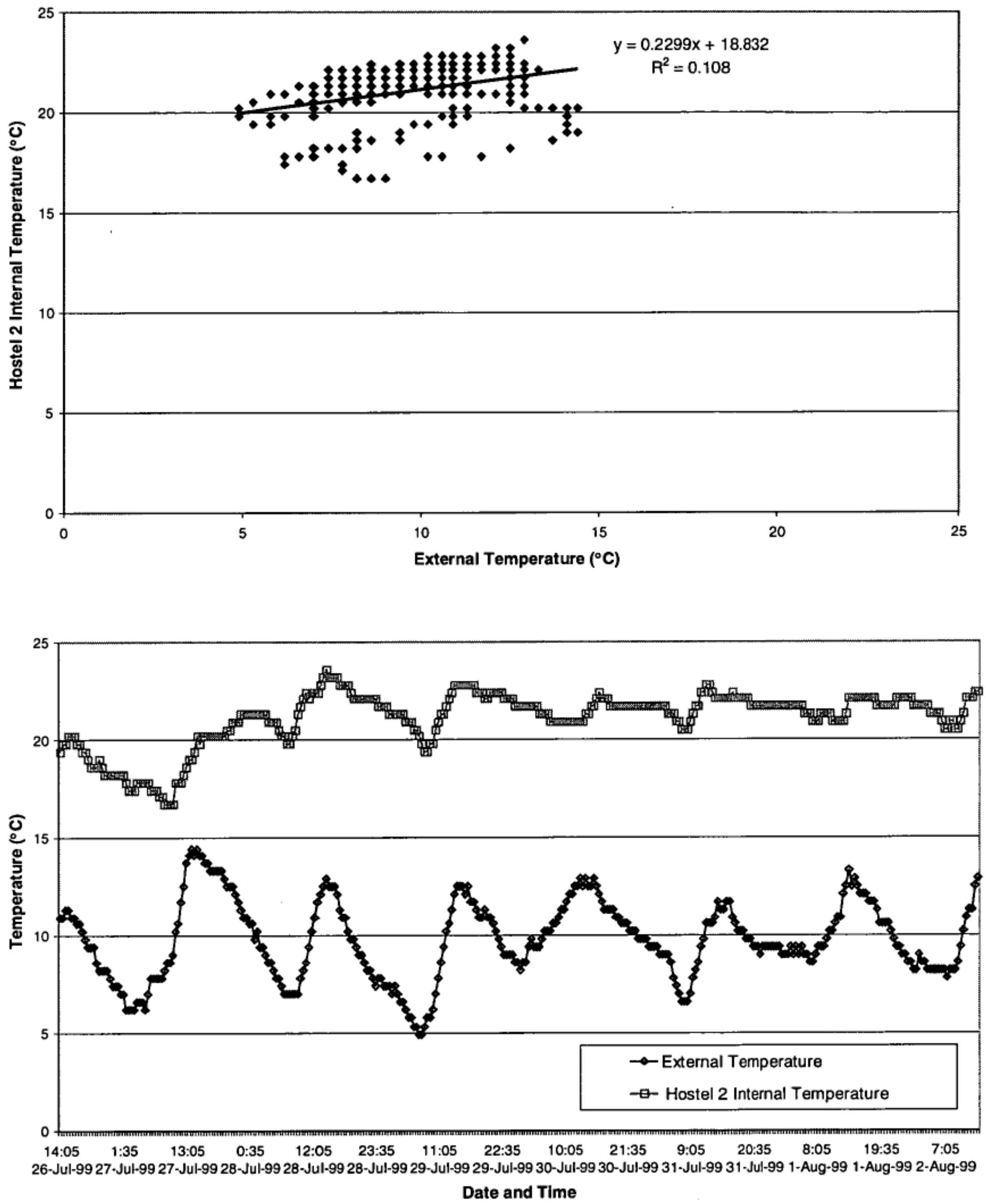


FIGURE 4.31

Temperature graph for hostel 2 residential room in Organisation B

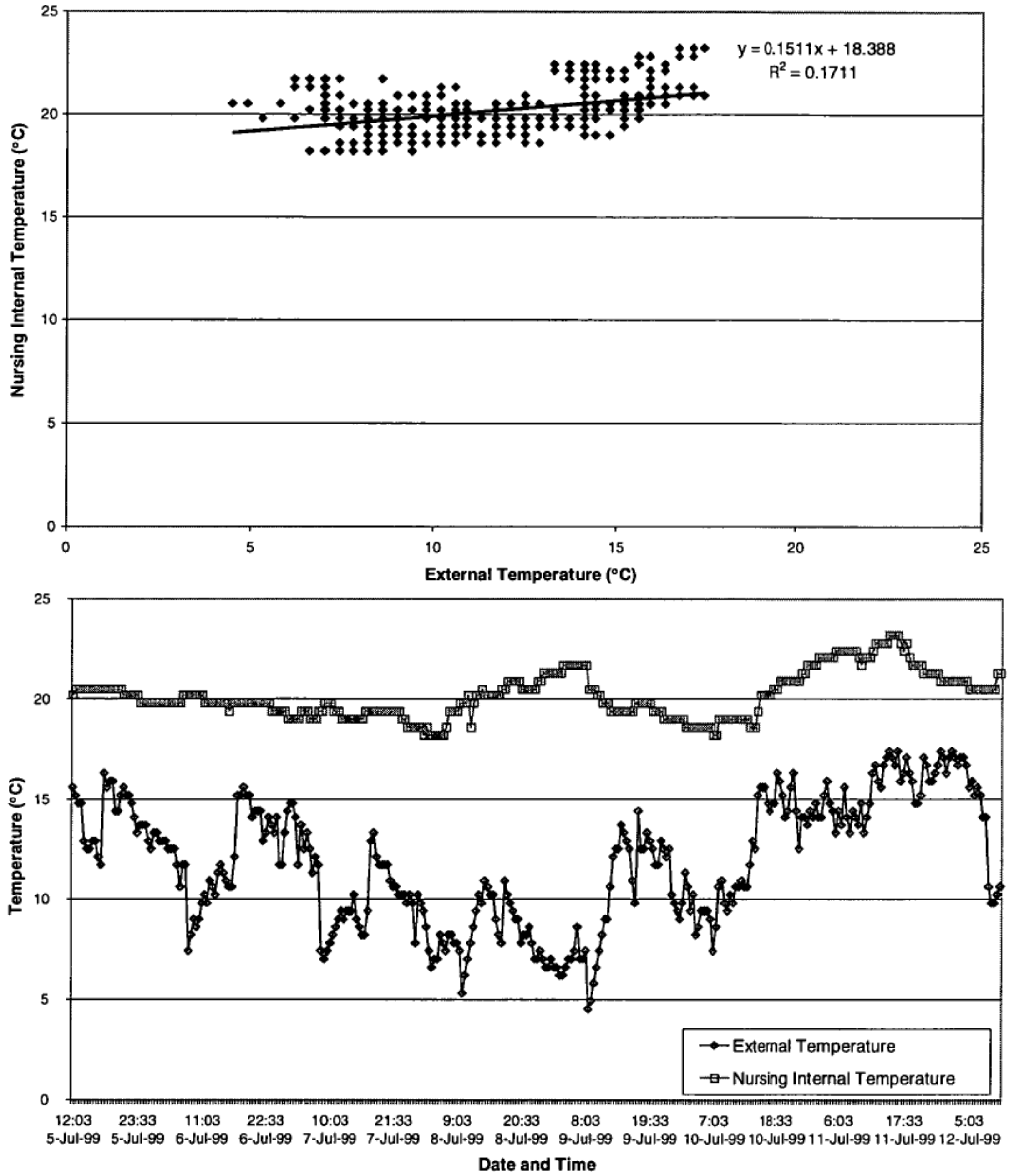
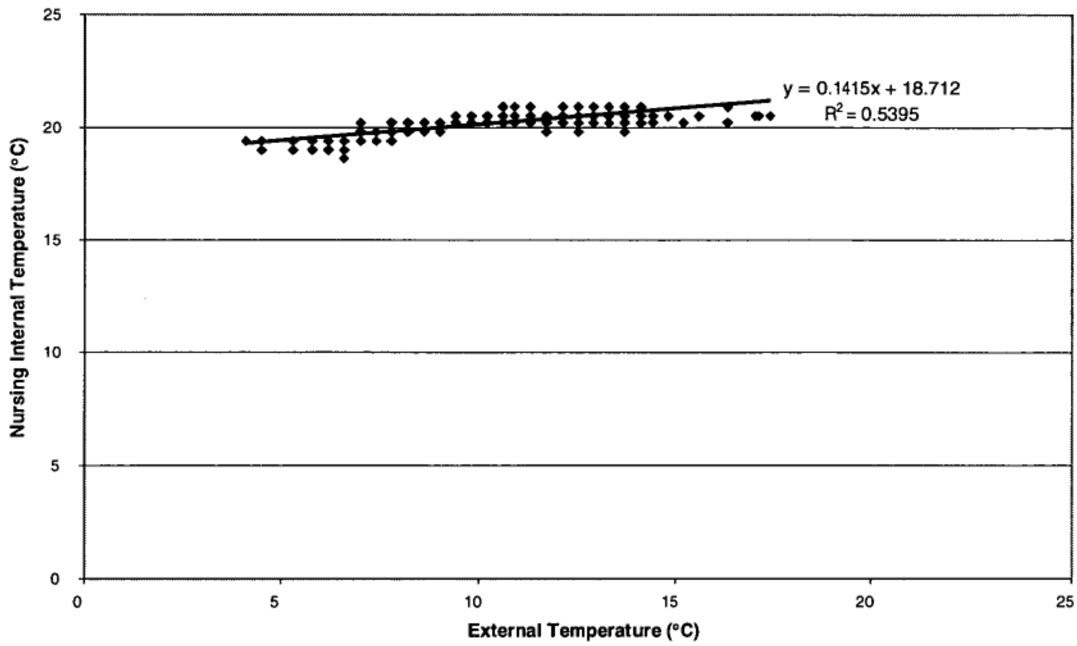


FIGURE 4.32

Temperature graph for nursing residential room in Organisation C



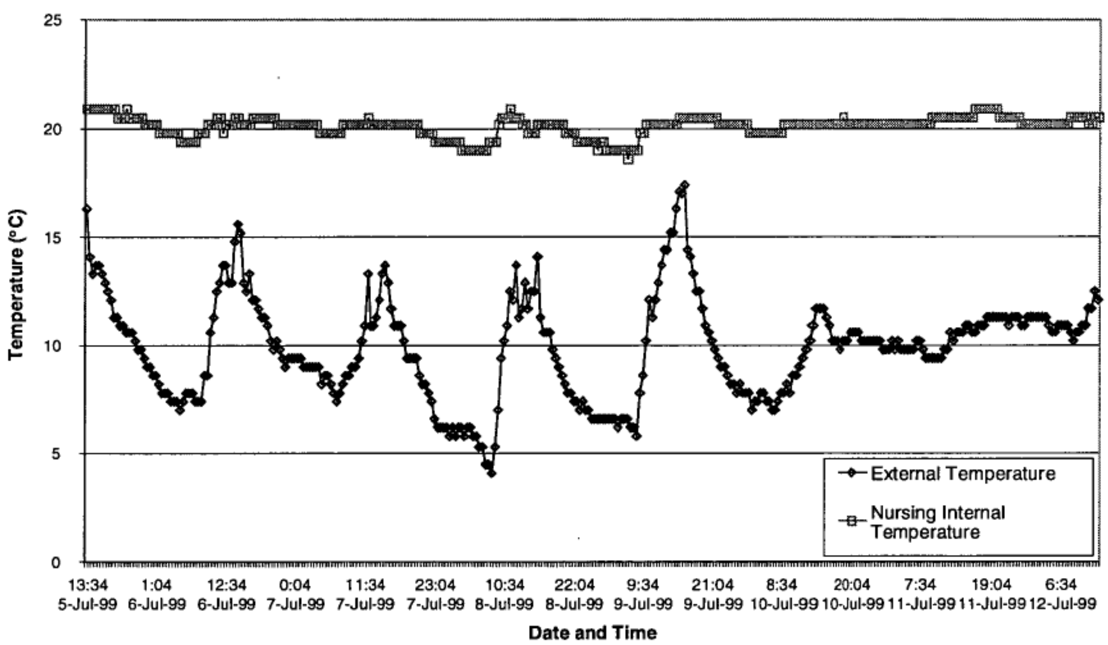
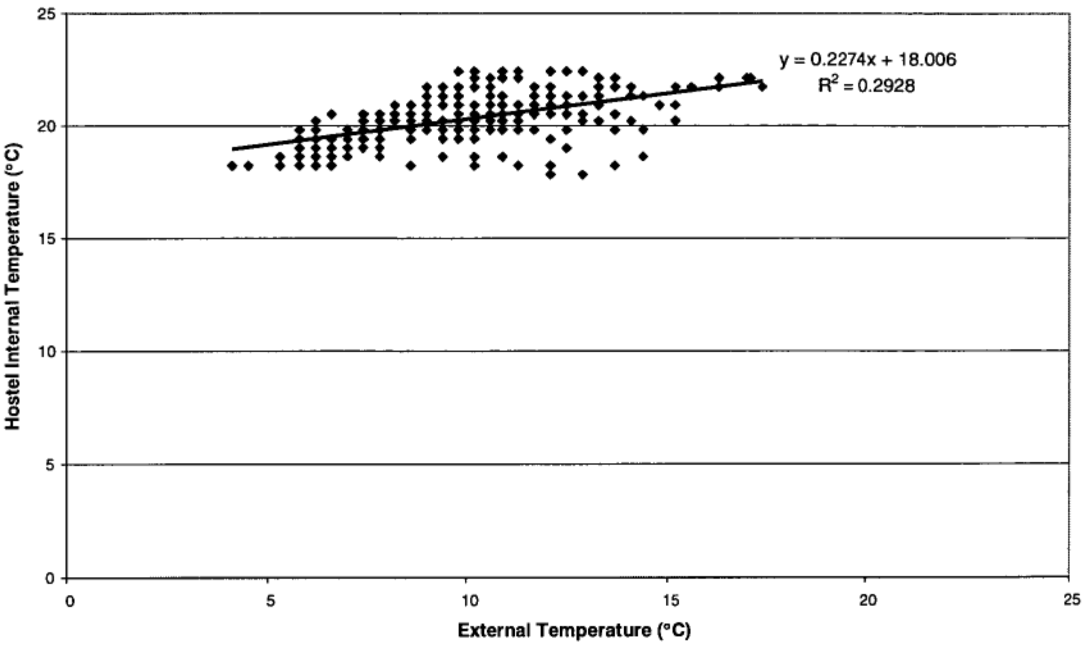


FIGURE 4.33
Temperature graph for nursing residential room in Organisation D



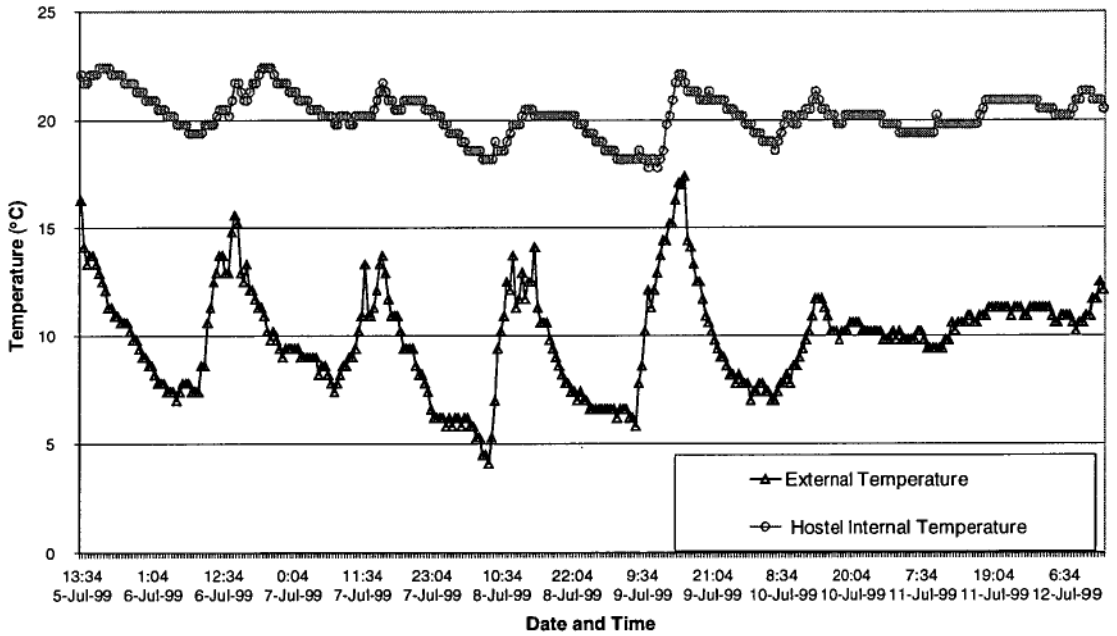


FIGURE 4.34

Temperature graph for hostel residential room in Organisation D

4.2.2 Comparisons of Energy Performances Between the Four Organisations

There was a relationship between outdoor air temperatures and gas consumption in all organisations. However, the relationships between outdoor air temperatures and gas consumption were greater in the organisations that had gas heaters. The more temperature dropped, the more gas was needed to heat the rooms. In organisations where gas heaters were used most frequently, the relationship between external temperature and gas consumption was strongest. For instance, gas heaters in communal rooms of Organisation A were more frequently used than gas heaters in recreation rooms of the Organisation B. Hence, the increase in gas consumption during cold weather was greater in Organisation A than in Organisation B.

There was also strong seasonal variation in the levels of electricity consumption for light and power and for winterpac off-peak with the highest consumption in winter and the lowest in summer for both of these tariffs in all organisations. This was partly due to seasonal changes in daylight hours and partly due to seasonal temperature changes. As the number of daylight hours declines in winter, lights need to be turned on longer. Lower air temperatures in winter result in greater electricity needs to heat the buildings. Hence, lighting had an effect only for electricity for light and power while heating had an effect for both light and power and winterpac off-peak. However, there was no relationship between electricity consumption for hot water and external temperatures within any organisation. Although low ambient temperatures during winter should increase electricity consumption via greater heat loss from hot water pipes and lower inlet water temperatures, this may have been balanced by greater volumes of hot water being used during summer. This would occur if residents have showers and baths more often in summer due to increased perspiration in warmer conditions. This explanation is supported by the fact that most hot water from electric hot water cylinders was used by residents for baths, showers and hand washing.

Levels of gas consumption were significantly different between the organisations because the numbers of residents and gas appliances in each organisation were different. This would affect the amount of gas needed for cooking, clothes drying, and hot water for kitchen and laundry. Moreover, the gas consumption index (kWh/m^2/resident) was highest in the organisation that had the largest total capacities of gas tumble driers. Organisation C, which had a gas consumption index approximately double that of the other three organisations, also had about double the total capacity of gas tumble driers of the others.

The significant differences between organisations in total annual electricity consumption could be attributed to differences in levels of electricity consumption in each of the areas of hot water, light and power, and winterpac off-peak.

The different levels of hot water electricity consumption between organisations was due to different numbers of residents, total capacities of electric hot water cylinders, and hot water system types between organisations. Organisation C had the lowest hot water electricity consumption index in both kWh/m^2 and kWh/resident because almost half of their electric hot water cylinders were low pressure systems. In contrast all electric hot water cylinders in Organisations A and D, and most cylinders in Organisation B, were mains pressure systems. In the low pressure systems, hot water is delivered at lower pressure and relies on gravity to generate pressure. In the mains pressure systems, hot water is delivered at the same pressure as cold water, resulting in more hot water flow into taps. Consequently, the electricity demand for the mains pressure hot water systems is generally higher than the demand for the low pressure systems. This may also have contributed to the lower electricity consumption index for hot water for Organisation B compared to the other two organisations. However, as only one of the ten cylinders in Organisation B was a low pressure system, this only made a small contribution to electricity savings in this organisation. The major reason for the lower electricity consumption index for hot water in Organisation B, than in Organisations A and D, was the lower volume of electric hot water storage per resident. Organisation D had a poor electricity consumption index for hot water because of the greater heat loss through their hot water pipes, associated with the longer distances between cylinders and hot water taps than the other organisations, and the use of a circulating hot water system. However, some of the heat loss associated with this system was reduced by covering most parts of their hot water pipes with rubber insulation.

The levels of consumption in both light and power and winterpac off-peak electricity varied between organisations and the seasonal patterns of variation also differed between organisations. These were probably mostly due to differences in the types of lighting and heating equipment used, and partly because the levels of building insulation and the floor areas were different in each organisation. In addition, the proportions of heaters connected to light and power electricity and winterpac off-peak electricity differed between organisations. Organisation D used off-peak storage underfloor heaters as their main heaters. This organisation also used electric convectional heating that used light and power electricity, and off-peak storage column heaters for additional heat in their residential rooms. Therefore, seasonal fluctuations in electricity consumption in Organisation D were due to winterpac off-peak rather than light and power. On the other hand, Organisation C used electric convection heaters that used light and power electricity as their main heaters, while off-peak storage column heaters were only used in the dining rooms. Hence the light and power electricity consumption for Organisation C varied greatly with the seasons while that for winterpac off-peak was always low, but still showed the same pattern. However, the main heaters for Organisations A and B were connected with both winterpac off-peak and light and power electricity. Off-peak storage convection and underfloor heaters that connected with winterpac off-peak were used in both Organisations A and B. Radiant heaters and oil fill column heaters that connected with light and power electricity were also used in both organisations. In addition, Organisation B used a heat pump and some electric convection heaters that connected with light and power electricity as well. As a result, both Organisations A and B exhibited strong seasonal fluctuations in both light and power and winterpac off-peak electricity.

Reductions in electricity demand for lighting could be achieved in all organisations by using lamps which are more energy efficient. At the time of the study, incandescent globes were used in at least some parts of all organisations. All organisations used incandescent lamps as their only means of outdoor lighting. Organisations C and D also used incandescent globes in all of their residential rooms. However, Organisations A and B only used incandescent globes in residential rooms in some older buildings. Residential rooms in other old buildings and all new buildings used more efficient compact fluorescent lamps or fluorescent tubes.

From the measurement of air temperatures, the indoor air temperature control of the A nursing 2 was the best of any rooms. This can be attributed to this room having a higher level of thermal resistance than any of the other rooms. This was due to insulation (R2.4) of the roof/ceiling space, as well as floors cork over the concrete floor. In addition, the north facing normal size window in the room was covered with a long fitted curtain with pelmet box. This room was heated by a floor heater and additional electric convection heater.

The four rooms with reasonable temperature control consisted of A hostel 1, and three nursing residential rooms; A nursing 1, D nursing, and C nursing. The internal air temperatures in these nursing residential rooms were controlled by staff. These rooms had levels of additional thermal resistance on their roof/ceiling space of R1.2, R1.2, R2.23, and R1.73 respectively. A nursing 1 and A hostel 1 used oil filled column heaters, and C nursing used electric a convection heater while D nursing used both a floor heater and an electric convection heater. At any given external temperature, the internal temperature in A hostel 1 was lower than in the other three rooms. This was partly because the other three rooms each had one normal size window, whereas A hostel 1 had a glass door which was larger than a normal size window. Hence, the heat loss through a glass door was greater.

The five rooms with poor temperature control were B nursing 1, and four hostel residential rooms; D hostel, B hostel 2, B hostel 1, and A hostel 2. The internal air temperatures in hostel residential rooms were controlled by hostel residents. These rooms had the levels of additional thermal resistance on their uninsulated roof/ceiling space of R0, R2.23, R1.63, R1.63, and R1.2 respectively. At any given external temperature, D hostel, B hostel 2, and B hostel 1 had higher internal temperatures than B nursing 1 and A hostel 2. D hostel and B hostels 1 and 2 all used electric convection heaters, while D hostel also had a floor heater. The benefits of better roof insulation in D hostel than the other two were negated somewhat by heat loss through a big glass door while the other two had normal sized glass windows. An oil-filled column heater was used in A hostel 2, while a wall mounted radiant strip heater was used in B nursing 1. A hostel 2 had a glass wall while B nursing 1 had a normal size window with inner roller shutter and curtain with pelmet box. Therefore, heat loss though the wall in A hostel 2 was greater than in B nursing 1. This difference in heat loss rates was exacerbated by the types of heaters used, because the air in A hostel 2 was warmed by the convection heater whereas the radiant heater in B nursing 1 only warmed the object at which it was directed rather than the air.

The worst temperature control room was in B nursing 1. This room had the lowest level of thermal resistance R0 for additional insulation for roof and a north facing wall consisting entirely of glass. The low internal temperature in this room was a consequence of this poor insulation and the use of a radiant heater.

Organisation D had the lowest annual total energy consumption index, followed by Organisation A, C and B respectively. This pattern reflected their respective total electricity consumption indices as well as electricity consumption indices for light and power and winterpac off-peak, with Organisation D being the lowest and Organisation B highest for each of these. These were generally related to the electricity used for heating, as well as the building insulation levels.

CHAPTER 5

COMPARISONS AND RECOMMENDATIONS

This chapter investigates how to improve energy efficiency in Tasmanian aged care buildings. The chapter comprises two major parts. The first part presents the results and discussion for step 2 of the preliminary audit. This includes energy performances for Tasmanian aged care buildings and an estimation of energy savings potential. The second part presents the results and discussion for the detailed audit. This includes recommendations and implementation plans for improving energy efficiency in Tasmanian aged care organisations.

5.1 Energy Performances and Estimation of Energy Savings Potential for Tasmanian Aged Care Buildings

Energy consumption in Tasmanian aged care buildings was predominantly in the form of electricity rather than gas (Table 5.1). Electricity for light and power was the largest proportion of the total electricity use, followed by institutional hot water, and winterpac off-peak (Table 5.1).

Energy sectors	Percentage of total energy used	Energy Consumption indices (kWh/m^2)
Electricity for light and power	44.7%	105
Electricity for institutional hot water	19.1%	45
Electricity for winterpac off-peak	18.3%	43
Total Electricity	82.1%	193
Liquefied petroleum gas (LPG)	17.9%	42
Total Energy	100%	235

TABLE 5.1
Average percentage of total energy used and average energy consumption indices in each sector for four Tasmanian aged care buildings

Gas was used only for cooking, clothes drying, hot water heating for kitchens and/or laundries, and space heating in a few areas of main buildings. The rest of the equipment related to energy use was powered by electricity. This encompassed lighting, hot water cylinders as well as space heaters in most areas of main buildings, refrigerators, freezers, washing machines, printers, photocopying machines, and computers. Electricity consumption for winterpac off-peak was used exclusively for space heating, while institutional hot water electricity was used only for hot water heating. However, electricity consumption for light and power was used for most of the other electrical equipment including some space heaters.

The Tasmanian aged care buildings studied had applied some energy efficiency features that resulted in reductions in energy costs and consumption. These energy saving technologies included an electric heat pump, high pressure sodium lamps, compact fluorescent lamps, fluorescent tubes, automatic door closers, and weather strips around doors and windows.

Nevertheless, in general, energy performances in Tasmanian aged care organisations were still poor relative to the best practice energy standards in the UK and Denmark. This was because the buildings were poorly insulated, as well as the use of inefficient energy technologies in many areas of the buildings. For instance, Tasmanian aged care buildings had lower levels of additional insulation for roofs and walls than those recommended by the Standards Association of Australia and those defined under UK regulations (Table 5.2). Additional insulation levels for floors were also lower than those required under UK legislation. Tasmanian aged care buildings also often had poorly protected single pane windows, including glass walls, skylights and vented skylights, in many heated areas of the buildings. Double glazing was not installed in the four aged care organisations studied. These shortcomings, together with the use of individual electric space heaters rather than central heating systems, would result in high heating costs. Moreover, in many areas of the buildings, such as residential rooms and corridors, and in outdoor lighting, low efficiency incandescent lamps were used. Despite the high demand for hot water, the use of equipment to restrict hot water demand, such as low flow shower heads, were not present. Hence, all of these energy inefficiency areas in Tasmanian aged care organisations could be improved.

Construction	United Kingdom building regulations	Australian standards recommended for buildings in Hobart	Observations of aged care buildings in Hobart, Tasmania
Ceiling	R4.0	R3.0	None – R2.4
Walls	R2.2	R1.5 - R2	None
Floor	R2.2	No recommendation	None – R0.14
Windows	R0.3*	No recommendation	None – R0.2

TABLE 5.2
Summary of the minimum R-values (m^2K/W) for ceilings, walls, floors, and windows required under the United Kingdom regulations (adapted from DOE 1997a: 2); the minimum R-values recommended for additional insulation of buildings in Hobart, Australia (SAA 1993); and the R-values observed for additional insulation of the four Tasmanian aged care organisations in Hobart.
*The R-values for windows under the UK building regulations depends on the percentage of wall area that is glass. The values showing here is that for glass comprising 13% of the wall area.

The average total energy consumption index for Tasmanian aged care buildings in 1999 was 235 kWh/m^2 (Table 5.1). This index was 63 kWh/m^2 or 36.6% higher than the UK annual energy consumption standard of less than 172 kWh/m^2, and 111 kWh/m^2 or 89.5% higher than the average annual energy consumption of 124 kWh/m^2 for Denmark. Therefore, average energy saving potential for Tasmanian aged care organisations was estimated as at least 63 kWh/m^2. This was calculated from the difference between the annual energy consumption index of Tasmania and United Kingdom. Hence, to be able to achieve the best practice energy standards for aged care buildings, the energy consumption index for the Tasmanian aged care organisation have to be reduced by at least 63 kWh/m^2 or around 26.8% of their average annual energy consumption in 1999.

The energy consumption in Tasmanian aged care buildings was particularly large in the areas of space heating, lighting, and water heating. Energy consumption for clothes drying and washing, cooking, office equipment, and refrigeration was also considerable. Hence, major energy savings potential for Tasmanian aged care buildings exist in these areas.

5.2 RECOMMENDATIONS AND IMPLEMENTATION PLANS

This section uses the investigations of energy performances for Tasmanian aged care buildings, obtained by conducting energy audits, to develop recommendations and implementation plans for aged care organisations in Tasmania.

5.2.1 Recommendations

The possible energy saving measures most appropriate for the areas of energy inefficiencies in Tasmanian aged care buildings are detailed in this section. The recommendations made include financial evaluations for some energy saving measures that require capital investments.

To illustrate the financial evaluations of various energy saving measures for Tasmanian aged care buildings, consider the following example. A typical Tasmanian aged care organisation that is located in Hobart, provides accommodation for 106 residents. This organisation has a total floor area for the main buildings of 5360 m^2. Hence, by using the energy consumption indices from Table 5.1, annual energy consumption for this aged care organisation is calculated in Table 5.3 below.

Energy sectors	Annual energy consumption in kWh
Electricity for light and power	(105 kWh/m^2 × 5360 m^2) = 562800 kWh
Electricity for institutional hot water	(45 kWh/m^2 × 5360 m^2) = 241200 kWh
Electricity for winterpac off-peak	(43 kWh/m^2 × 5360 m^2) = 230480 kWh
Total Electricity	(193 kWh/m^2 × 5360 m^2) = 1034480 kWh
Liquefied petroleum gas (LPG)	(42 kWh/m^2 × 5360 m^2) = 225120 kWh
Total Energy	(235 kWh/m^2 × 5360 m^2) = 1259600 kWh

TABLE 5.3
Energy consumption for a typical Tasmanian aged care organisation

	Construction and insulation materials
Roofs	Tile deck roofs, fibreglass batts 70mm (R1.5)
Walls	Brick veneer with no additional insulation
Floor	Concrete floor with no additional insulation
Windows	Single glazing, metal frames, and long fitted curtain with pelmets

TABLE 5.4
Lists of roof, wall, floor and window constructions for a typical Tasmanian aged care organisation

This organisation has an average ceiling height of 2.8 metres. Constructions of this organisation are listed in Table 5.4. The organisation has 22 vented and 10 unvented skylights, glass walls, and big windows in many areas of the main buildings (30% of wall area is windows). Numerous electric space heaters, such as oil-fill column, low wall convection, and off-peak storage convection heaters, are used to heat the entire area of the main buildings. Different types of lighting globe are used such as 60W incandescent lamps in residential rooms, and 36W fluorescent tubes in corridor areas. The organisation has 66 existing exterior light fittings, with a 150 Watt incandescent bulb installed in each, for lighting the area outside the main buildings to maintain an illumination of 40 lux. Hot water used in kitchen and laundry is supplied from mains pressure gas hot water cylinders, while in other areas the supply is provided by mains pressure electric hot water cylinders. The organisation provides 48 showers and 5 baths for the residents and 53 hand basin taps for both staff and residents.

Economic calculations were made using the latest prices of Tasmanian electricity for the year 2000 (Table 5.5), and the annual discount rate of 5%. All prices in the financial evaluations are exclusive of sales tax or GST.

Electricity tariffs	Costs ($/kWh)
Nursing homes light and power – first 500 kWh per quarter	0.12391
Nursing homes light and power – next 500 kWh per quarter	0.09634
Nursing homes light and power – remainder	0.07492
Institutional hot water – all kWh	0.07416
Winterpac off-peak with afternoon boost period – all kWh	0.05951

TABLE 5.5

Electricity cost in dollars per kWh for Tasmanian aged care organisations in the year 2000 (http://www.auroraenergy.com.au/brochures/rate42k.pdf: 4/05/2000)

5.2.1.1 Housekeeping

Generally, it is possible to make some energy cost savings without the need of financial investment in most Tasmanian aged care buildings. This involves basic housekeeping measures that use existing building and equipment as efficiently as possible. Good housekeeping measures for Tasmania aged care buildings include (DOE 1996c, Energy Information Centre 1997b):

- ensuring doors and windows close properly;
- check that space heater and hot water thermostats are correctly set;

- look for hot water leaks from mains, taps and showers and carry out repairs where necessary;
- repair damaged or misplaced hot water cylinder and pipe insulation;
- check regularly for gas leaks, and repair immediately, and regularly maintain the sealant in lubricated valves because poorly maintained valves are almost certain to leak;
- turn off all lights when not in use;
- regularly clean all luminaries, lamps and windows;
- clothes washers, driers and dishwashers should be full when used;
- clean the coils at the back of a refrigerator from time to time to prevent the build up of fluff;
- check temperature settings on fridges and freezers, mark and set at the temperatures consistent with food preservation;
- switch printers off overnight and weekends;
- turn off office equipment when not in use for long periods; and
- when equipment items have to be replaced, choose a more energy efficient model.

5.2.1.2 Energy saving measures for hot water energy consumption

Electricity consumption for hot water, particularly showers and hand basin taps, can be substantially decreased through the use of appropriate hot water control devices such as controlled flow shower roses and flow control valves to reduce the amount of hot water use. Controlled flow shower roses, sometimes called low flow shower heads, are designed to reduce the amount of water used in a shower without reducing the quality of the shower. This is possible because, even though the amount of water used in a flow controlled shower is reduced, the velocity is greater than that in a normal shower (http://www.dpie.gov.au/netenergy/house/ roses.html: 15/03/2000). In Tasmania, they are available for a flow rate of 9 litres per minute. Flow control valves, sometimes called flow restrictors, are small cylindrical devices which can be connected behind taps to restrict the amount of water used (http://www.dpie.gov.au/ netenergy/house/roses.html: 15/03/2000). In Tasmania, they are available for flow rates of 5, 7, 9, and 12 litres per minute. Both controlled flow shower roses and flow control valves can be easily fitted to existing showers without the need of a plumber.

Calculations for financial evaluations of these two measures are presented below. These calculations assume a flow rate of water from the existing showers and taps in a typical Tasmanian aged care organisation to be 15 litres per minute.

5.2.1.2.1 Energy saving measure for hot water showers

A controlled flow shower rose with 9 litres per minute flow rate costs $68 (current Tasmanian prices). Investment costs for purchasing this device for the 48 showers are $3264 ($68 × 48). Total annual electricity cost for hot water is $17887 (241200 kWh × 0.07416 $/kWh). If hot water use for showers is contributing 25% of the total hot water consumption (Section 4.2.1.2), the cost of hot water electricity for showers is $4472 per year ($17887 × 0.25) and the electricity consumption is 60300 kWh per year (241200 kWh × 0.25). After installing controlled flow shower roses with 9 litres per minute flow rate to existing showers, around 40% (6 litres ÷ 15 litres) of electricity consumption and cost for hot water used for showers is saved. Hence, the annual electricity consumption saving from installing controlled flow shower roses is 24120 kWh (60300 kWh/year × 0.4) or around 4.5 kWh/m^2/year (24120 kWh/year ÷ 5360 m^2). This provides a cost saving of $1789 per year ($4472 × 0.4). This equates to a payback period for the controlled flow shower roses of approximately 1 year and 10 months ($3264 ÷ $1789 = 1.82 year), and is therefore a worthwhile investment.

5.2.1.2.2 Energy saving measure for hot water hand basin taps

A flow control valve with 7 litres per minute flow rate costs 13 dollars (current Tasmanian prices). Investment costs for purchasing this device for the 53 hand basin taps are $689 ($13 × 53). Total annual electricity costs for hot water are $17887 (241200 kWh × 0.07416 $/kWh). If hot water use for hand basin taps is contributing 9% of the total hot water consumption (Section 4.2.1.2), the cost of hot water electricity for hand basin taps is $1610 per year ($17887 × 0.09) and the electricity consumption is 21708 kWh per year (241200 kWh × 0.09). After installing flow control valves with 7 litres per minute flow rate to existing hand basin taps, 53.33% (8 litres ÷ 15 litres) of electricity consumption and cost for hot water used for the taps is saved. Hence, annual electricity consumption savings from flow control valves is 11577 kWh (21708 kWh/year × 0.5333), or around 2.16 kWh/m^2/year (11577 kWh/year ÷ 5360 m^2). This represents cost savings of $859 per year ($1610 ×

0.5333). Consequently, the payback period for the flow control valves is approximately 10 months ($689 ÷ $859 = 0.80 year), and this is a very worthwhile investment.

5.2.1.3 Energy saving measures for lighting electricity consumption

5.2.1.3.1 Outdoor lighting energy saving measures

Two energy saving measures will be considered for the outdoor lighting of a typical Tasmanian aged care organisation. The first measure is to replace each existing incandescent bulb with a 33 Watt compact fluorescent lamp (CFL). The alternative measure is to install five new 300 Watt high pressure sodium (HPS) light fittings to replace the 66 existing light fittings. Both of these actions will provide similar levels of lighting output to the original system. However, the reduced wattage of both corrective actions will substantially lower electricity consumption. A reduction of 78% will result from the CFL option, while the HPS option will give approximately an 85% decrease (Table 5.6). Details of the capital costs, energy consumption, and annual savings of the two measures are given in Table 5.7.

Types of lighting globe	Wattage in each lamp	Number of lamps	Total wattage
Incandescent lamp	150	66	9900
Compact fluorescent lamp	33	66	2178
High pressure sodium lamp	300	5	1500

TABLE 5.6
Outdoor lighting total wattage comparisons between using 150 Watt incandescent lamps, 33 Watt compact fluorescent lamps, or 300 Watt high pressure sodium lamps

Year	Annual cost for incandescent lamps ($)	Annual cost for electricity saving measures ($)		Annual cash flows ($)	
		CFL	HPS	CFL	HPS
Investment	0	1518	2165 (170 + 1995)	-1518	-2165
End year 1	3037 (330 + 2707)	596 (0 + 596)	410 (0 + 410)	2441	2627
End year 2	3037 (330 + 2707)	596 (0 + 596)	410 (0 + 410)	2441	2627
End year 3	3037 (330 + 2707)	2114 (1518 + 596)	410 (0 + 410)	923	2627
End year 4	3037 (330 + 2707)	596 (0 + 596)	410 (0 + 410)	2441	2627
End year 5	3037 (330 + 2707)	2114 (1518 + 596)	580 (170 + 410)	923	2457
End year 6	3037 (330 + 2707	596 (0 + 596)	410 (0 + 410)	2441	2627
End year 7	3037 (330 + 2707)	2114 (1518 + 596)	410 (0 + 410)	923	2627
End year 8	2971 (264 + 2707)	596 (0 + 596)	410 (0 + 410)	2375	2561

TABLE 5.7
Comparison of capital and electricity costs of 66 incandescent bulbs of 150 W, 66 compact fluorescent lamps (CFL) of 33 W, and five high pressure sodium lamps (HPS) of 300 W

Calculations assume: lighting used 10 hours per day (3650 hours of use per year); costs of $0.07492 per kWh of electricity (current Tasmanian prices); costs of $1 for each incandescent lamp, $23 for each CFL lamp, and $34 for each HPS lamp (current Tasmanian prices); a cost of $399 for each HPS fitting (current Tasmanian prices); and lives of 750 hours for each 150 Watt incandescent lamp, 7500 hours for each 33 Watt compact fluorescent lamp, and 15000 hours for each 300 Watt high pressure sodium lamp (Energy Information Centre 1997c). It should be noted that the labour cost for lamp changing is not included in this example.

Annual costs for the existing light system consist of replacing globes at each fitting an average of just under five times per year plus electricity consumption of $2707 (0.150 kW × 66 lamps × 3650 hours × 0.07492 $/kWh). Hence for the first seven years, the cost is 66 fittings × 5 globes at $1 each = $330, but in the eighth year, the cost will be 66 fittings × 4 globes at $1 each = $264. Costs for the CFL measure comprise capital costs of 66 lamps at $23 each ($1518) every second year plus annual electricity costs of 22% those of incandescent bulbs. For the HPS option, costs consist of five lamps at $34 each ($170) every fourth year plus annual electricity costs of 15.15% those of incandescent bulbs. In addition, an initial capital cost of $1995 for the five fittings is incurred when selecting the HPS measure. From these data, annual cash flows can be calculated by subtracting the annual costs associated with each energy saving measure from the annual costs arising from the existing situation (Table 5.7). Financial evaluation calculations are conducted as follow.

Firstly, calculations of the payback period for the CFL and HPS measures, using data from Table 5.7 are:

- approximately 7 months ($1518 ÷ $2441/year = 0.62 years) for the CFL action; and
- approximately 10 months ($2165 ÷ $2627/year = 0.82 years) for the HPS action.

From the payback period calculations the CFL investment seems to be a better investment because of shorter payback period than the HPS investment. The net present value was also used to investigate which measure is a better energy saving investment, even though their payback periods are less than 3 years (Table 5.8).

The positive NPVs in all years for both the CFL and HPS measures (Table 5.8) indicate this investment provides consistent profits even when the annual discount rate is as high as 5%. The NPVs for the CFL measure for year 1 and year 2 are higher than the NPV values for the HPS measure. However, the NPV of HPS action overtakes the NPV of CFL measure after three years, indicating that the HPS measure is the better long-term investment. The annual electricity consumption saving from the HPS measure is (0.15 kW × 66 lamps × 3650 hours) – (0.3 kW × 5 lamps × 3650 hours) = 30660 kWh, or around 5.7 kWh/m^2/year (30660 kWh/year ÷ 5360 m^2).

Year	CFL	NPV (5%) Calculations and formulas in MS Excel for CFL
End year 1	$768.34	=NPV(5%,-1518,2441)
End year 2	$2876.97	=NPV(5%,-1518,2441,2441)
End year 3	$3636.33	=NPV(5%,-1518,2441,2441,923)
End year 4	$5548.91	=NPV(5%,-1518,2441,2441,923,2441)
End year 5	$6237.67	=NPV(5%,-1518,2441,2441,923,2441,923)
End year 6	$7972.44	=NPV(5%,-1518,2441,2441,923,2441,923,2441)
End year 7	$8597.17	=NPV(5%,-1518,2441,2441,923,2441,923,2441,923)
End year 8	$10128.11	=NPV(5%,-1518,2441,2441,923,2441,923,2441,923,2375)
Year	HPS	NPV (5%) Calculations and formulas in MS Excel for HPS
End year 1	$320.86	=NPV(5%,-2165,2627)
End year 2	$2590.16	=NPV(5%,-2165,2627,2627)
End year 3	$4751.40	=NPV(5%,-2165,2627,2627,2627)
End year 4	$6809.73	=NPV(5%,-2165,2627,2627,2627,2627)
End year 5	$8643.18	=NPV(5%,-2165,2627,2627,2627,2627,2457)
End year 6	$10510.14	=NPV(5%,-2165,2627,2627,2627,2627,2457,2627)
End year 7	$12288.19	=NPV(5%,-2165,2627,2627,2627,2627,2457,2627,2627)
End year 8	$13939.04	=NPV(5%,-2165,2627,2627,2627,2627,2457,2627,2627,2561)

TABLE 5.8

NPV calculations for installing CFL or HPS external lighting for a typical Tasmanian aged care organisation (based on data in Table 5.7 and assuming a 5% annual discount rate)

5.2.1.3.2 Residential room lighting energy saving measure

An energy saving measure is considered for residential room lighting which involves replacing each existing 60 Watt incandescent bulb with a 13 Watt compact fluorescent lamp (CFL). The CFL measure will provide similar levels of lighting output to the original system. However, the reduced wattage of this measure will substantially lower electricity consumption by 78% (Table 5.9).

Types of lighting globe	Wattage in each lamp	Number of lamps	Total wattage
Incandescent lamp	60	106	6360
Compact fluorescent lamp	13	106	1378

TABLE 5.9

Residential room lighting total wattage comparisons between using existing 60 Watt incandescent lamps or 13 Watt compact fluorescent lamps

Details of the capital costs, energy consumption, and annual savings of this CFL measure are given in Table 5.10. Calculations assume: lighting used 3 hours per day (1095 hours of use per year); costs of \$0.07492 per kWh of electricity (current Tasmanian prices); costs of \$1 for each incandescent lamp, and \$23 for each CFL (current Tasmanian prices); and lives of 750 hours for each 60 Watt incandescent lamp, and 7500 hours for each 13 Watt compact fluorescent lamp (Energy Information Centre 1997c). It should be noted that the labour cost for lamp changing is not included in this example.

Year	Annual cost for incandescent lamps	Annual cost saving for CFL measure (\$)	Annual cash flows for CFL measure (\$)
Investment	0	2438	-2438
End year 1	628 (106 + 502)	113 (0 + 113)	515
End year 2	628 (106 + 502)	113 (0 + 113)	515
End year 3	734 (212 + 502)	113 (0 + 113)	621
End year 4	628 (106 + 502)	113 (0 + 113)	515
End year 5	734 (212 + 502)	113 (0 + 113)	621
End year 6	628 (106 + 502)	113 (0 + 113)	515
End year 7	734 (212 + 502)	2551 (2438 + 113)	-1817
End year 8	628 (106 + 502)	113 (0 + 113)	515
End year 9	734 (212 + 502)	113 (0 + 113)	621
End year 10	628 (106 + 502)	113 (0 + 113)	515
End year 11	734 (212 + 502)	113 (0 + 113)	621
End year 12	628 (106 + 502)	113 (0 + 113)	515
End year 13	628 (106 + 502)	113 (0 + 113)	515
End year 14	734 (212 + 502)	2551 (2438 + 113)	-1871
End year 15	628 (106 + 502)	113 (0 + 113)	515
End year 16	734 (212 + 502)	113 (0 + 113)	621
End year 17	628 (106 + 502)	113 (0 + 113)	515
End year 18	734 (212 + 502)	113 (0 + 113)	621
End year 19	628 (106 + 502)	113 (0 + 113)	515
End year 20	734 (212 + 502)	113 (0 + 113)	621
End year 21	628 (106 + 502)	2551 (2438 + 113)	-1923

TABLE 5.10

Comparison of capital and electricity costs for 106 incandescent bulbs of 60 W and 106 compact fluorescent lamps (CFL) of 13 W

Annual costs for the existing light system consist of replacing globes at each fitting an average of above once per year plus electricity consumption of \$522 (0.06 kW × 106 lamps × 1095 hours × 0.07492 \$/kWh). Hence for the years 1, 2, 4, 6, 8, 10, 12, 13, 15, 17, 19, and 21, the cost is 106 fittings × 1 globe at \$1 each = \$106; but for the years 3, 5, 7, 9, 11, 14, 16, 18, and 20, the cost will be 106 fittings × 2 globes at \$1 each = \$212. Costs for the CFL measure comprise capital costs of 106 lamps at \$23 each (\$2438) every seven years plus annual electricity costs of 22% those of incandescent bulbs. From these data, annual cash flows can be calculated by subtracting the annual costs associated with each energy saving measure from the annual costs arising from the existing situation (Table 5.10). Financial evaluation calculations are conducted as follows.

Calculations of the payback period for the CFL measure, using data from Table 5.10 are approximately 4 years and 9 months ($2438 ÷ $515/year = 4.73 years) for the CFL action. From the calculation, the CFL investment is a medium term action with payback period over 3 years. Therefore, the net present value was also used to investigate whether this measure is a worthwhile investment (Table 5.11).

Year	NPV (5%)	Calculations and formulas in MS Excel for CFL
End year 1	-$1854.78	=NPV(5%,-2438,515)
End year 2	-$1409.91	=NPV(5%,-2438,515,515)
End year 3	-$899.01	=NPV(5%,-2438,515,515,621)
End year 4	-$495.49	=NPV(5%,-2438,515,515,621,515)
End year 5	-$32.09	=NPV(5%,-2438,515,515,621,515,621)
End year 6	$333.91	=NPV(5%,-2438,515,515,621,515,621,515)
End year 7	-$895.91	=NPV(5%,-2438,515,515,621,515,621,515,-1817)
End year 8	-$563.94	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515)
End year 9	-$182.70	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621)
End year 10	$118.41	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621,515)
End year 11	$464.21	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621,515,621)
End year 12	$737.32	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621,515,621,515)
End year 13	$997.43	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621,515,621,515, 515)
End year 14	$97.45	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621,515,621,515, 515,-1871)
End year 15	$333.38	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621,515,621,515, 515,-1871,515)
End year 16	$604.32	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621,515,621,515, 515,-1871,515,621)
End year 17	$818.31	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621,515,621,515, 515,-1871,515,621,515)
End year 18	$1064.06	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621,515,621,515 ,515,-1871,515,621,515,621)
End year 19	$1258.16	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621,515,621,515, 515,-1871,515,621,515,621,515)
End year 20	$1481.06	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621,515,621,515, 515,-1871,515,621,515,621,515,621)
End year 21	$823.69	=NPV(5%,-2438,515,515,621,515,621,515,-1817,515,621,515,621,515, 515,-1871,515,621,515,621,515,621,-1923)

TABLE 5.11

NPV calculations for installing CFL lighting in 106 residential rooms in a typical Tasmanian aged care organisation (based on data in Table 5.10 and assuming a 5% annual discount rate)

The net present value for the CFL measured from year 1 to year 5 are negative values. However, the CFL measure starts making profits against annual discount rate of 5% six years after the initial capital outlay. Nevertheless, the net present values for the CFL measure from year 7 to year 9 are negative values again, since another investment for 106 compact fluorescent lamps that need to be replaced every 7 years was required. The CFL starts making profits against annual discount rate of 5% again 10 years after the initial lamps replacing investment. Furthermore, all of the NPV of CFL after 10 years are positive values, even though the lamps must be replaced every 7 years. This indicates that the CFL measure is a long term investment providing consistent profit after 10 years when the annual discount rate is 5%. Annual electricity consumption savings from the CFL measure will be (0.06 kW × 106 lamps × 1095 hours) – (0.013 kW × 106 lamps × 1095 hours) = 5455 kWh, or around 1.02 kWh/m^2/year (5455 kWh/year ÷ 5360 m^2).

5.2.1.4 Energy saving measures for heating energy consumption

To illustrate the financial evaluations for heating energy saving measures, in this typical Tasmanian aged care organisation, consider the following example. Assume that the electricity consumption for heating is the average of the four aged care organisations in Chapter 4 (Table 5.12). Total annual heating electricity consumption from Table 5.12 is 415453 kWh (230480 kWh + 184973 kWh) which comprises winterpac off-peak electricity (55%) and light and power electricity (45%).

Season	Winterpac off-peak electricity indices for heating in kWh/m^2	Winterpac off-peak electricity use for heating in kWh	Percentage of total winterpac off-peak electricity
Summer	2.89	15490	7%
Autumn	8.95	47972	21%
Winter	19.30	103448	45%
Spring	11.86	63570	28%
Annual	43.00	230480	100%
Season	**Light and power electricity indices for heating in kWh/m^2**	**Light and power electricity use for heating in kWh**	**Percentage of total light and power electricity**
Summer	2.84	15222	3%
Autumn	4.50	24120	4%
Winter	17.84	95622	17%
Spring	9.33	50009	9%
Annual	34.51	184973	33%

TABLE 5.12

Average annual and seasonal electricity indices and consumption for heating for the four Tasmanian aged care organisations

Heating electricity consumption varies between seasons because of differences in outdoor air temperatures while indoor air temperatures are kept more or less constant. Indoor air temperature for this typical Tasmanian aged care building is assumed to remain constant at 19°C. Air temperature differences between indoor and outdoor for each season are calculated in Table 5.13, using seasonal mean daily temperature for Hobart (BoM 1999) as outdoor air temperatures.

Season	Mean daily temp. (°C)[1]	Temperature differences between indoor and outdoor (°C)
Summer	16.4	2.6
Autumn	13.2	5.8
Winter	8.6	10.4
Spring	12.3	6.7

TABLE 5.13

Seasonal mean daily temperature for Hobart ([1]adapted from BoM 1999) and the air temperature differences between indoor (19°C) and outdoor for the typical aged care organisation

Season	Area (m^2)	Temperature differences (°C)	R-value of roofs (m^2C/W)	Heat loss (kW)	Number of hours	Total heat loss (kWh)
Summer	5360	2.6	1.84	7.57	2160	16360
Autumn	5360	5.8	1.84	16.90	2208	37306
Winter	5360	10.4	1.84	30.30	2208	66893
Spring	5360	6.7	1.84	19.52	2160	42158
Annual						162716

TABLE 5.14

Calculations of annual heat loss through the roofs (kWh) for a typical Tasmanian aged care organisation

Season	Building perimeter (m)	Ceiling height (m)	Window and wall area (m^2)	Wall area 70% (m^2)	Temp differ (°C)	R-value of walls (m^2C/W)	Heat loss (kW)	Number of hours	Total heat loss (kWh)
Summer	545	2.8	1526	1068	2.6	0.54	5.14	2160	11102
Autumn	545	2.8	1526	1068	5.8	0.54	11.47	2208	25326
Winter	545	2.8	1526	1068	10.4	0.54	20.57	2208	45419
Spring	545	2.8	1526	1068	6.7	0.54	13.25	2160	28620
Annual									110467

TABLE 5.15

Calculations of annual heat loss through the walls (kWh) for a typical Tasmanian aged care organisation

Season	Building perimeter (m)	Ceiling height (m)	Window and wall area (m^2)	Window area 30% (m^2)	Temp differ (°C)	R-value of windows (m^2C/W)	Heat loss (kW)	Number of hours	Total heat loss (kWh)
Summer	545	2.8	1526	458	2.6	0.36	3.31	2160	7142
Autumn	545	2.8	1526	458	5.8	0.36	7.38	2208	16285
Winter	545	2.8	1526	458	10.4	0.36	13.23	2208	29202
Spring	545	2.8	1526	458	6.7	0.36	8.52	2160	18404
Annual									71032

TABLE 5.16

Calculations of annual heat loss through the windows (kWh) for a typical Tasmanian aged care organisation

Season	Area (m^2)	Ceiling height (m)	Air volume (m^3) for 2 ACH	Temperature differences (°C)	Energy required (kWh)	Heat loss (kW)	Number of hours	Total heat loss (kWh)
Summer	5360	2.8	30016	2.6	0.00034	26.53	2160	57314
Autumn	5360	2.8	30016	5.8	0.00034	59.19	2208	130695
Winter	5360	2.8	30016	10.4	0.00034	106.14	2208	234350
Spring	5360	2.8	30016	6.7	0.00034	68.38	2160	147693
Annual								570051

TABLE 5.17

Calculations of annual heat loss through ventilation (kWh) for a typical Tasmanian aged care organisation

Rate of heat loss through different parts of buildings such as roofs, walls, and windows can be calculated by using the formula below (Todd 1994c):

$$HL = \frac{A \times TD}{R}$$

Where HL is the rate of heat loss (W),
A is the area of the wall, ceiling, window etc. (m^2),
TD is the temperature difference between indoor and outdoor (°C),
R is the R-value (m^2C/W).

Annual heat loss through roofs, walls, windows and ventilation for this typical Tasmanian aged care organisation are calculated and shown in Tables 5.14, 5.15, 5.16, and 5.17. The rates of heat loss vary in relation to R-values of the surface objects and the air temperature differences between indoor and outdoor. For ventilation heat loss calculations, the 0.34 Watts used as electricity consumption is the amount required to heat one cubic metre of air by one degree Celsius in one hour (Todd 1994c). R-values used for this typical Tasmanian aged care building are: R1.84 for roofs (R0.34 uninsulated tile roof and R1.5 fibreglass batts), R0.54 for walls (R0.54 uninsulated brick veneer), and R0.36 for windows (R0.16 single glazed and R0.2 curtains with close fitted pelmets) (Todd 1994c). Ventilation rate in total for this buildings is assumed to be 2 air changes per hour (ACH). Hence the air volume loss through ventilation is 30016 m^3 per hour ($5360m^2 \times 2.8m \times 2ACH$). However, in this example, heat losses through the floor have not been included because the rate of heat loss is subject to numerous unknown variables. It is assumed to be zero. The calculations also do not take into account heat loss from unheated areas in the buildings such as kitchen and laundry. It must be emphasised that these calculations are only approximations. The purpose of these calculations is only to illustrate examples for financial calculations of recommended energy saving measures.

Areas	Total heat loss (kWh/year)
Roofs	162716
Walls	126280
Windows	71032
Ventilation	570051
Building in whole	930079

TABLE 5.18

Summary heat loss in different areas of a typical Tasmanian aged care buildings and the total heat loss for the whole building (from Tables 5.14 – 5.17)

If the internal temperature of a building remains constant, its total heat gain must be equal to its total heat loss (Thumann 1998: 134). However, the heat gain of this typical Tasmanian aged care building from total annual heating electricity consumption of 415453 kWh (Table 5.12) is much less than the calculated total heat loss of this building of 930079 kWh (Table 5.18).

The 514626 kWh extra heat can be attributed to other sources such as solar radiant energy, as well as heat given off by equipment, lamps, and people. Average solar gain from a north facing window in Hobart is approximately 3 kWh/m^2/day (Todd 1994c). This figure is similar for winter and summer and takes cloudiness into account. If windows are distributed equally on all sides of a square building, the annual solar gain through the north facing windows would be about 125000 kWh (3 kWh/m^2/day $\times$ 365 days/year $\times$ 458 m^2 $\times$ 0.25). The combined annual solar gain through east, west and south windows is around 1.5 times the annual solar gain from the north windows (Todd 11/07/00, *pers. comm.*). Hence, the total annual solar gain for the building would be about 313000 kWh. In addition, each person gives off about 80 to 100 Watts of heat (Todd 11/07/00, *pers. comm.*). If 106 residents stay in the building for one year, they will provide about 93000 kWh (106 residents $\times$ 365 days/year $\times$ 24 hours/day $\times$ 0.1 kW) of heat. As about 98% of total energy input to incandescent lamps is converted to heat (Energy Victoria 1994: 25), annual heat gain from 60 Watt incandescent lamps from residential rooms can be around 6800 kWh (98% $\times$ 0.06 kW $\times$ 1095 hours/year $\times$ 106 lamps). Hence, these three sources provide around 413000 kWh of extra heat per annum. Further additional heat gain will occur through roofs and walls and other equipment, although this is difficult to quantify. Hence, these factors can account for the calculated discrepancy between total annual heating electricity consumption and heat loss of 514626 kWh/year.

Three energy saving actions are recommended for reductions in heating energy consumption in this typical Tasmanian aged care organisation. In order of economic worth, these are: 1) seal off some vented skylights to reduce heat loss from excessive ventilation; 2) add more insulation to the roof; and 3) install double glazing to replace each existing single pane window.

5.2.1.4.1 Sealing vented skylights and installation of transparent diffusers

Assume that the average airflow of a typical Tasmanian aged care organisation is 1 m/s (a measured number from page 104 in Chapter 4), and the size of a vented skylight is 1m × 1m, with a 5 cm permanent gap. Ventilation loss from 22 skylights of this typical Tasmanian aged care organisation will be:

$$1 \text{ m/s} \times (4\text{m} \times 0.05\text{m}) \times 3600 \text{ s/h} = 720 \text{ m}^3/\text{h}$$

$$(720 \text{ m}^3/\text{h} \times 22 \text{ skylights}) \div (5360 \text{ m}^2 \times 2.8 \text{ m}) = 1.05 \text{ air changes per hour}$$

The overall ventilation rate for this organisation comprises the ventilation rate of 1.05 air changes per hour from 22 vented skylights plus other ventilation from avenues such as bathroom and kitchen vents, wall vents, cracks around doors and windows, and open doors and windows. Hence, the overall ventilation rate of this typical Tasmanian aged care organisation is likely to be more than adequate for this building. An energy saving action for this organisation is to seal half of the total number for vented skylights with transparent diffusers. Consequently, 11 vented skylights are sealed with transparent diffusers and 11 vented skylight remain.

Season	Area (m^2)	Ceiling height (m)	Air volume (m^3) of 1.05ACH	Temperature differences (°C)	Energy required (kWh)	Heat loss (kW)	Number of hours	Total heat loss (kWh)
Summer	5360	2.8	15758	2.6	0.00034	13.93	2160	30090
Autumn	5360	2.8	15758	5.8	0.00034	31.08	2208	68615
Winter	5360	2.8	15758	10.4	0.00034	55.72	2208	123034
Spring	5360	2.8	15758	6.7	0.00034	35.90	2160	77539
Annual								299277

TABLE 5.19

Calculations of annual heat loss through 22 skylights (1.05 ACH)

The annual heat loss through 22 skylights is 299277 kWh (Table 5.19). Hence, sealing half of these skylights will result in energy savings of 149638.5 kWh, or around 27.92 kWh/m² (149638.5 kWh ÷ 5360 m²). The resultant energy cost savings are $5045 for light and power electricity (149638.5 kWh × 45% × $0.07492 per kWh) plus $4898 for winterpac off-peak (149638.5 kWh × 55% × $0.05951 per kWh). Hence, this action will lead to a total electricity cost saving of $9943.

The cost of a transparent diffuser (including installation and sealing cost) is $110 (current Tasmanian prices). Hence the cost of sealing 11 vented skylights is $1210

(\$110 × 11 skylights). The payback period for this measure is around 1 month (\$1210 ÷ \$9943 = 0.12 year). Hence, this is a very worthwhile investment.

5.2.1.4.2 Adding additional roof insulation

Two energy saving measures will be considered for insulating the roofs. The first measure is to install additional fibreglass batts 70mm (R1.5) insulation on the existing roofs. This will increase the R-value of the existing roof from R1.84 to R3.34, and result in a level of additional insulation which meets the minimum R-values recommended from the Standards Association of Australia (Table 5.2). The alternative measure is to install additional loose filled rockwool (R2.5) insulation in the existing roofs. This will increase the R-value of the existing roofs to R4.34 which will meet the minimum R-values under the United Kingdom regulations (Table 5.2).

Season	Area (m^2)	Temperature differences (°C)	R-value of the existing roof plus additional R1.5 fibreglass batts (m^2C/W)	Heat loss (kW)	Number of hours	Total heat loss (kWh)
Summer	5360	2.6	3.3	4.17	2160	9013
Autumn	5360	5.8	3.3	9.31	2208	20552
Winter	5360	10.4	3.3	16.69	2208	36851
Spring	5360	6.7	3.3	10.75	2160	23225
Annual						89640
Season	**Area (m^2)**	**Temperature differences (°C)**	**R-value of the existing roof plus additional R2.5 loose filled rock wool (m^2C/W)**	**Heat loss (kW)**	**Number of hours**	**Total heat loss (kWh)**
Summer	5360	2.6	4.3	3.21	2160	6936
Autumn	5360	5.8	4.3	7.16	2208	15816
Winter	5360	10.4	4.3	12.84	2208	28360
Spring	5360	6.7	4.3	8.27	2160	17873
Annual						68985

TABLE 5.20

Calculations of annual heat loss through the roofs after installing additional R1.5 fibreglass batts or R2.5 loose filled rockwool

Fibreglass batts (R1.5) cost \$3.60 per m^2 and their installation costs \$10 per $9m^2$ (current Tasmanian prices). Hence, the investment cost for the first measure is \$25256 (fibreglass batts cost of \$19296 plus installation cost of \$5960). After installing additional R1.5 fibreglass batts on the existing roof, 73076 kWh (162716 kWh (Table 5.14) - 89640 kWh (Table 5.20)) of heating electricity consumption is saved. Hence, annual electricity consumption savings from installing R1.5 fibreglass batts is 13.63 kWh/m^2 (73076 kWh ÷ 5360 m^2). This electricity saving consumption comprises 32884 kWh (73076 kWh × 45%) of light and power electricity and 40192 kWh (73076 kWh × 55%) winterpac off-peak electricity. Therefore, the annual energy saving cost from installing R1.5 fibreglass batts is \$2464 (32884 kWh × \$0.07492 per kWh) plus \$2392 (40192 kWh × \$0.05951 per kWh), giving a total of \$4856. Therefore, the payback period of this measure is 5 years and 2 months (\$25256 ÷ \$4856 = 5.2 years).

Loose filled rockwool insulation (R2.5) costs \$48 per $9m^2$ (including installation costs) (current Tasmanian prices). Hence, the investment cost for the loose filled rockwool measure is \$28608 (\$48/$9m^2$ × $5360m^2/9m^2$). After installing additional R2.5 loose filled rockwool in the existing roof 93731 kWh (162716 kWh (Table 5.14) - 68985 kWh (Table 5.20)) of heating electricity consumption is saved. Hence, annual electricity consumption savings from installing R2.5 loose filled rockwool is 17.49 kWh/m^2 (93731 kWh ÷ 5360 m^2). This electricity saving consumption comprises 42179 kWh (93731 kWh × 45%) of light and power electricity and 51552 kWh (93791 kWh × 55%) of winterpac off-peak electricity. Therefore, the annual energy saving cost from installing R2.5 loose filled rockwool is \$3200 (42719 kWh × \$0.07492 per kWh) plus \$3068 (51552 kWh × \$0.05951 per kWh), giving a total of \$6268. Therefore, the payback period of this measure is 4 years and 7 months (\$28608 ÷ \$6268 = 4.59 years).

From the payback period calculations the loose filled rockwool investment is a slightly better investment than the fibreglass batts investment. However, both loose filled rockwool and fibreglass batt investments are medium term actions with payback periods of over 3 years. Therefore, the net present value was also used to investigate whether these measures are worthwhile investments, and which measure is the better energy saving investment.

The greater initial investment of the R2.5 loose filled rockwool than for the R1.5 fibreglass batts results in a worse NPV value during the first two years (Table 5.21). However, the greater energy savings from the loose filled rockwool option results in this being more profitable than the fibreglass batt option after three years, and thereafter becomes an increasingly better investment than fibreglass batts. Hence, it takes five years for the NPV of the rockwool option to become positive, but six years for the fibreglass batts (Table 5.21).

Year	NPV (5%)	Calculations and formulas in MS Excel for R1.5 fibreglass batts
End year 1	-$19648.80	=NPV(5%,-25256,4856)
End year 2	-$15454.00	=NPV(5%,-25256,4856,4856)
End year 3	-$11458.96	=NPV(5%,-25256,4856,4856,4856)
End year 4	-$7654.16	=NPV(5%,-25256,4856,4856,4856,4856)
End year 5	-$4030.53	=NPV(5%,-25256,4856,4856,4856,4856,4856)
End year 6	-$579.47	=NPV(5%,-25256,4856,4856,4856,4856,4856,4856)
End year 7	$2707.27	=NPV(5%,-25256,4856,4856,4856,4856,4856,4856,4856)
End year 8	$5837.49	=NPV(5%,-25256,4856,4856,4856,4856,4856,4856,4856,4856)
End year 9	$8818.65	=NPV(5%,-25256,4856,4856,4856,4856,4856,4856,4856,4856,4856)
End year 10	$11657.85	=NPV(5%,-25256,4856,4856,4856,4856,4856,4856,4856,4856,4856,4856)
Year	NPV (5%)	Calculations and formulas in MS Excel for R2.5 loose filled rockwool
End year 1	-$21560.45	=NPV(5%,-28608,6268)
End year 2	-$16145.92	=NPV(5%,-28608,6268,6268)
End year 3	-$10989.22	=NPV(5%,-28608,6268,6268,6268)
End year 4	-$6078.08	=NPV(5%,-28608,6268,6268,6268,6268)
End year 5	-$1400.80	=NPV(5%,-28608,6268,6268,6268,6268,6268)
End year 6	$3053.75	=NPV(5%,-28608,6268,6268,6268,6268,6268,6268)
End year 7	$7296.18	=NPV(5%,-28608,6268,6268,6268,6268,6268,6268,6268)
End year 8	$11336.59	=NPV(5%,-28608,6268,6268,6268,6268,6268,6268,6268,6268)
End year 9	$15184.60	=NPV(5%,-28608,6268,6268,6268,6268,6268,6268,6268,6268,6268)
End year 10	$18849.37	=NPV(5%,-28608,6268,6268,6268,6268,6268,6268,6268,6268,6268,6268)

TABLE 5.21

NPV calculations for installing the additional R1.5 fibreglass batts or R2.5 loose filled rockwool insulation on to the existing roofs

As installation of R2.5 loose filled rockwool yields better returns on investment than installation of additional R1.5 fibreglass batts, on both payback period and NPV calculations, it is the better option for reducing heat loss through the roofs. This action will also lead to greater energy savings than installation of additional fibreglass batts.

5.2.1.4.3 Replacing single pane windows with double glazing windows

The energy saving measure to reduce window heat loss to be considered is the replacement of single glazing with double glazing on windows. This measure will increase the R-value of the existing window from R0.36 to R0.52 when the curtains are closed (double glazing R0.32 plus R0.2 of curtains with pelmets (Todd 1994c)).

Cost of double glazing windows (included installation cost) is $254 per m^2 (current Tasmanian prices). Hence, the investment cost for the double glazing windows is $116332 (458 m^2 × $254). After replacing double glazing windows, 21856 kWh (71032 kWh (Table 5.16) - 49176 kWh (Table 5.22)) of heating electricity consumption is saved. This translates to annual electricity consumption savings of 4.08 kWh/m^2 (21856 kWh ÷ 5360 m^2). This electricity consumption saving comprises 9835 kWh (21856 kWh × 45%) of light and power electricity and 12021 kWh (21856 kWh × 55%) of winterpac off-peak electricity. Therefore, the annual energy saving cost from double glazing windows is $737 (9835 kWh × $0.07492 per kWh) plus $715 (12021 kWh × $0.05951 per kWh), giving a total of $1452. Hence, the payback period for the double glazing windows measure is 80 years and 1 month ($116332 ÷ $1452 = 80.12 years).

Season	Building perimeter (m)	Ceiling height (m)	Window and wall area (m^2)	Window area 30% (m^2)	Temp differ (°C)	R-value after replacing with double glazed window (m^{2}C/W)	Heat loss (kW)	Number of hours	Total heat loss (kWh)
Summer	545	2.8	1526	458	2.6	0.52	2.29	2160	4944
Autumn	545	2.8	1526	458	5.8	0.52	5.11	2208	11275
Winter	545	2.8	1526	458	10.4	0.52	9.16	2208	20216
Spring	545	2.8	1526	458	6.7	0.52	5.90	2160	12741
Annual									49176

TABLE 5.22

Calculations of annual heat loss through the windows after replacement with double glazing windows in a typical aged care organisation

NPVs for replacement of single pane windows with double glazing were negative throughout the first 28 years (Table 5.23). However, it was not possible to determine the time when NPVs become positive because the calculations became to complex after 28 years for the Excel program to calculate them. Hence, although this action represents a saving of energy under the current prices in Tasmania, this is not economically viable.

However, if all curtains are open during the heating period, double glazing will double the R-value from R0.16 to R0.32. Hence, after double glazing, 79911.5 kWh (159823 kWh – 79911.5 kWh (Table 5.24)) of heating electricity consumption is saved. This translates to an annual electricity consumption saving of 14.91 kWh/m^2 (79911.5 kWh ÷ 5360 m^2). This electricity saving consumption comprises 35960 kWh (79911.5 kWh × 45%) of light and power electricity and 43951 kWh (79911 kWh × 55%) of winterpac off-peak electricity. Therefore, the annual energy saving cost from double glazing windows is $2694 (35960 kWh × $0.07492 per kWh) plus $2915 (43951 kWh × $0.05951 per kWh), giving a total of $5606. Therefore, the payback period for replacement of single pane windows with double glazing is 20 years and 9 months ($116332 ÷ $5606 = 20.75 years).

Year	NPV (5%)	Calculations and formulas in MS Excel for double glazing measure (close curtains)
End year 1	-$109,475	=NPV(5%,-116332,1452)
End year 2	-$108,221	=NPV(5%,-116332,1452,1452)
End year 3	-$107,027	=NPV(5%,-116332,1452,1452,1452)
End year 4	-$105,889	=NPV(5%,-116332,1452,1452,1452,1452)
End year 5	-$104,805	=NPV(5%,-116332,1452,1452,1452,1452,1452)
End year 6	-$103,773	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452)
End year 7	-$102,791	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452)
End year 8	-$101,855	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452)
End year 9	-$100,963	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452)
End year 10	-$100,114	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452)
End year 11	-$99,306	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452)
End year 12	-$98,536	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452)
End year 13	-$97,802	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452)
End year 14	-$97,104	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452)
End year 15	-$96,439	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452)
End year 16	-$95,805	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452)
End year 17	-$95,202	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452,1452)
End year 18	-$94,627	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452,1452,1452)
End year 19	-$94,080	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452,1452,1452,1452)
End year 20	-$93,559	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452,1452,1452,1452,1452)
End year 21	-$93,063	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452,1452,1452,1452,1452,1452)
End year 22	-$92,590	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452)
End year 23	-$92,140	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452)
End year 24	-$91,711	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452)
End year 25	-$91,302	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452)
End year 26	-$90,914	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452)
End year 27	-$90,543	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452)
End year 28	-$90,190	=NPV(5%,-116332,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452,1452, 1452,1452,1452)

TABLE 5.23

NPV calculations for replacing existing single glass with double glazing measure (close curtains) in a typical Tasmanian aged care organisation

Season	Building perimeter (m)	Ceiling height (m)	Window and wall area (m^2)	Window area 30% (m^2)	Temp differ (°C)	R-value of existing single glass window with open curtains (m^2C/W)	Heat loss (kW)	Number of hours	Total heat loss (kWh)
Summer	545	2.8	1526	458	2.6	0.16	7.44	2160	16069
Autumn	545	2.8	1526	458	5.8	0.16	16.60	2208	36642
Winter	545	2.8	1526	458	10.4	0.16	29.76	2208	65703
Spring	545	2.8	1526	458	6.7	0.16	19.17	2160	41408
Annual									159823
Season	**Building perimeter (m)**	**Ceiling height (m)**	**Window and wall area (m^2)**	**Window area 30% (m^2)**	**Temp differ (°C)**	**R-value after replacing double glazed window with open curtains (m^2C/W)**	**Heat loss (kW)**	**Number of hours**	**Total heat loss (kWh)**
Summer	545	2.8	1526	458	2.6	0.32	3.72	2160	8034
Autumn	545	2.8	1526	458	5.8	0.32	8.30	2208	18321
Winter	545	2.8	1526	458	10.4	0.32	14.88	2208	32852
Spring	545	2.8	1526	458	6.7	0.32	9.59	2160	20704
Annual									79911

TABLE 5.24

Calculations of annual heat loss through the existing windows (open curtains) (R0.16), and after replacing with double glazing windows (open curtains) (R0.32)

NPVs were again negative through out the first 28 years for replacing double glazing in open curtains areas (Table 5.25). As for the closed curtain situation, it was not possible to determine the point at which NPVs become positive because the calculations became to complex after 28 years for the Excel program to calculate them. Hence, although this represents in a saving of energy under the current prices in Tasmania, this is not economically viable.

However, after 28 years, the negative NPVs of replacing double glazing for closed curtains areas was about three times as high as that for open curtains areas (Tables 5.23 and 5.25). Hence, double glazing is a better investment in areas where curtains are open while heating is occurring, than in areas where curtains are closed.

Year	NPV (5%)	Calculations and formulas in MS Excel for double glazing measure (open curtains)
End year 1	-$105,708	=NPV(5%,-116332,5606)
End year 2	-$100,865	=NPV(5%,-116332,5606,5606)
End year 3	-$96,253	=NPV(5%,-116332,5606,5606,5606)
End year 4	-$91,860	=NPV(5%,-116332,5606,5606,5606,5606)
End year 5	-$87,677	=NPV(5%,-116332,5606,5606,5606,5606,5606)
End year 6	-$83,693	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606)
End year 7	-$79,899	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606)
End year 8	-$76,285	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606)
End year 9	-$72,843	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 10	-$69,566	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 11	-$66,444	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 12	-$63,471	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 13	-$60,640	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 14	-$57,943	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 15	-$55,375	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 16	-$52,929	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 17	-$50,600	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 18	-$48,381	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 19	-$46,268	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 20	-$44,256	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 21	-$42,340	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 22	-$40,514	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 23	-$38,776	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 24	-$37,121	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 25	-$35,544	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 26	-$34,043	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 27	-$32,613	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)
End year 28	-$31,251	=NPV(5%,-116332,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606,5606)

TABLE 5.25

NPV calculations for replacing existing single glass with double glazing measure (open curtains)

5.2.2 Implementation plans

Measures to raise the energy efficiency of Tasmanian aged care organisations to meet the UK best practice energy standards are achievable and economically viable. The six measures (listed in Table 5.26) will provide 93% of the target of 63 kWh/m^2, and the rest can be achieved by good housekeeping. Improving energy management and housekeeping can easily reduce total energy consumption by between 5 and 15% (DOE 1996c: 2). Collectively, short payback period measures, such as sealing vented skylights, installing hot water flow control valves, HPS for outdoor lighting, and controlled flow shower roses, can produce more than 60% of the target savings in a typical Tasmanian aged care building (Table 5.26). However, medium term measures, such as additional roof insulation and installing CFL for residential room lighting, may also be required to meet all of the target (Table 5.26). Moreover, to be able to maintain control of their energy consumption and costs, energy audits should be conducted regularly.

Energy saving measures	Payback period (years)	Annual energy saving (kWh/m^2)	Percentage for the energy saving target of 63 kWh/m^2	Cumulative percentage of target
Sealing vented skylights	0.12	27.92	44.3%	44.3%
Flow control valves	0.80	2.16	3.4%	47.7%
HPS for outdoor lighting	0.82	5.70	9.0%	56.7%
Controlled flow shower roses	1.82	4.50	7.1%	63.8%
Additional roof insulation (R2.5)	4.59	17.49	27.8%	91.6%
CFL for residential room lighting	4.73	1.02	1.6%	93.2%

TABLE 5.26

Energy saving measures, annual energy saving in kWh/m^2, and the percentage for the energy saving target of 63 kWh/m^2 for a typical Tasmanian aged care organisation

CHAPTER 6

CONCLUSION

This study indicates that using energy consumption indices from countries with best practice energy standards as a benchmark was useful as a method for investigating potential for improvements of energy efficiency in Tasmanian aged care buildings.

This study also indicates that conducting energy audits in the four Tasmanian aged care organisations was useful as a method for investigating energy consumption of Tasmanian aged care organisations. Nevertheless, the effectiveness of this approach to investigate energy performance in Tasmanian aged care organisations may be limited by a lack of data in areas such as historical building modifications. Moreover, the applicability of these findings to Tasmanian aged care organisations in general may be limited by the number of aged care organisations upon which energy audits were conducted. Four aged care organisations in Hobart areas may be an insufficient number to give the overall picture of aged care organisations in Tasmania. In further studies it could be worthwhile to conduct energy audits on a larger number of Tasmanian aged care organisations in many areas around the state to obtain a more representative sample.

The four Tasmanian aged care organisations differed substantially in their gas, electricity, and total energy consumptions. The annual energy consumptions per unit floor area for Organisations B and C were 9% and 6%, respectively, more than the average annual energy consumption of 235 kWh/m^2. In contrast, annual energy consumptions per floor area for Organisations A and D were 9% and 5%, respectively, less than this average. The annual gas consumption per floor area for Organisation C was far greater than that for the other three organisations, being 67% more than the average annual gas consumption of 42 kWh/m^2. This was in stark contrast to the annual gas consumptions per floor area for Organisations A, B, and D, which were 26%, 40%, and 2%, respectively, less than the average. This difference is explained in Chapter 4. The annual electricity consumption per floor area for Organisation B was 20% more than the average annual electricity consumption of

193 kWh/m^2 while the other organisations A, C, and D were less than the average (6%, 8%, and 5%, respectively).

The average energy cost for the Tasmanian aged care organisations in 1999 was approximately $851 per resident per year. This comprised the annual costs per resident of $148 for LPG, $173 for hot water electricity, $403 for light and power electricity, and $127 for winterpac off-peak electricity.

Approximately 24 percent, or $204 per resident, of this average annual energy cost can be saved if the energy saving measures discussed in Chapter 5 are implemented. These measures provide a good return on investment, as the initial cost is only $362 per resident, and would reduce energy consumption levels by 93% of the amount required to meet overseas best practice energy standards. Hence, there is ample opportunity to reduce energy consumption to levels comparable to overseas best practice energy standards in a cost-effective manner.

However, the accuracy of the findings in this study may be compromised by the numerous assumptions made during the calculations. These can be divided into assumptions relating to determination of the benchmark and those relating to energy saving measures.

As part of determining the benchmark, an assumption associated with fossil fuel consumption in the UK and Denmark was required. It was assumed that all of this consumption was used for space heating when, in reality, some would have been used for heating hot water. Consequently, all fossil fuel consumption was adjusted for differences in heating degree days between those countries and Hobart, although an unknown proportion of this fossil fuel consumption did not require adjustment.

Assumption in relations to energy saving measures can be divided between energy consumption for heating, lighting, and hot water. Calculations of payback periods for energy saving measures associated with areas where few assumptions were made are more likely to be accurate than those associated with areas with more assumptions.

The area with most assumptions was heating energy consumption. For the calculations of annual heat loss from a typical aged care organisation, average seasonal temperatures for outdoor and an assumption of uniform 19 °C throughout the whole building were used. However, in reality, the indoor and outdoor temperatures of buildings fluctuated from time to time, and indoor temperatures probably differed between different parts of the buildings. Hence, there may be substantial errors in calculations of annual heat loss, which will translate into inaccuracies in payback periods for additional roof insulation and sealing vented skylights. If annual heat loss is greater than that determined using these assumptions, payback periods will be less for both of these investments. Conversely, if annual heat loss is less than that determined using these assumptions, payback periods will be longer for both of these investments. Moreover, from the audit measurement, there is a problem of using an airflow anemometer to measure air leakage around vented skylights. Average wind speed was assumed to be 1 m/s. This may also lead to inaccuracies for heat loss calculations through skylights and, hence, calculations of payback period for sealing vented skylights. In further studies it may be advantageous to use an electronic data recorder, such as a dataflow recorder, instead of an airflow anemometer. The dataflow recorder that was used for measurements of air temperatures in this study can also be used to measure wind speed and direction by using a wind speed and direction sensor type. Using an electronic data recorder to record wind speed over a period of time will give a more accurate assessment of ventilation heat loss.

The only assumptions made in relation to lighting energy consumption were the assumptions of 10 hours use per day for outdoor lighting and 3 hours per day for indoor residential rooms lighting. However, in reality, the number of hours used for outdoor lighting and indoor residential lighting will vary with the season. This may lead to inaccuracies in calculations of payback periods for energy saving measures for lighting electricity consumption. For instance, if the use of indoor residential room lighting is less than 3 hours, the payback period will be more than that found in the calculation, whereas if the use is more than 3 hours, the payback period will be less than that found in the calculation.

The only assumption made in relation to hot water energy consumption is a flow rate of water from existing taps and showers of 15 litres per minute. This will affect calculations of payback periods for energy saving measures for hot water energy consumption. If the actual flow rate of water from existing taps and showers is less than 15 litres per minute, the payback period will be more than the calculation indicate, whereas if more than 15 litres per minute, the payback period will be less than the calculation indicate.

This study has provided baseline data, with which comparisons can be made after energy saving measures have been implemented. Such comparisons will allow the effectiveness of the measures to be assessed and, hence, the accuracy of the predictions to be determined.

This study has achieved its specific and overall aims. The first specific aim, to investigate the energy consumption of Tasmanian aged care organisations, was achieved by conducting energy audits in four Tasmanian aged care organisations. The second specific aim, to determine what are 'best practice energy standards for aged care buildings', was achieved by determining the energy consumption levels of the 25% of aged care buildings with the lowest annual consumptions per unit of floor area from each of the United Kingdom and Denmark. The last specific aim, to assess the energy performance of Tasmanian aged care organisations, was achieved by making comparisons to the best practice energy standards in the United Kingdom and Denmark. Hence, the overall aim of this study, to investigate how to improve energy efficiency in Tasmanian aged care buildings, was achieved by setting an energy reduction target and developing implementation plans to meet this target.

At the time of this study, Tasmanian aged care buildings did not meet the best practice energy standards in the United Kingdom and Denmark. Hence, the null hypothesis of *"Energy performance of Tasmanian aged care buildings meets overseas best practice energy standards"* was rejected.

It is hoped that this research will:

* stimulate Tasmanian aged care organisation towards energy conservation programs and energy audits, and increase understanding in conducting energy audits;
* reduce electricity and gas usage in Tasmania aged care organisations and, indirectly, reduce pollution and greenhouse gas emissions; and
* improve the way aged care organisations use energy, so that operating costs can be reduced and profitability improved.

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